

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

In the Matter of)	
)	
Use of Spectrum Bands Above 24 GHz for)	GN Docket No. 14-177
Mobile Radio Services)	
)	
Establishing a More Flexible Framework to)	IB Docket No. 15-256
Facilitate Satellite Operations in the)	
27.5-28.35 GHz and 37.5-40 GHz Bands)	
)	
Petition for Rulemaking of the Fixed Wireless)	RM-11664
Communications Coalition to Create Service)	
Rules for the 42-43.5 GHz Band)	
)	
Amendment of Parts 1, 22, 24, 27, 74, 80, 90,)	WT Docket No. 10-112
95 and 101 to Establish Uniform License)	
Renewal, Discontinuance of Operations, and)	
Geographic Partitioning and Spectrum)	
Disaggregation Rules and Policies for Certain)	
Wireless Radio Services)	
)	
Allocation and Designation of Spectrum for)	IB Docket No. 97-95
Fixed-Satellite Services in the 37.5-38.5 GHz,)	
40.5-41.5 GHz and 48.2-50.2 GHz Frequency)	
Bands; Allocation of Spectrum to Upgrade)	
Fixed and Mobile Allocations in the 40.5-42.5)	
GHz Frequency Band; Allocation of Spectrum)	
in the 46.9-47.0 GHz Frequency Band for)	
Wireless Services; and Allocation of Spectrum)	
in the 37.0-38.0 GHz and 40.0-40.5 GHz for)	
Government Operations)	

COMMENTS OF XO COMMUNICATIONS, LLC

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January 28, 2016

EXECUTIVE SUMMARY

XO Communications, LLC (“XO”) commends the Federal Communications Commission (“Commission”) for proposing a new flexible licensing and regulatory framework that will permit the deployment of 5G mobile radio services in commercial spectrum bands above 24 GHz. By making large swaths of upper microwave spectrum available for mobile broadband development, the Commission will realize extraordinary benefits for American consumers. XO is committed to the innovative use of its licensed upper microwave spectrum, and it strongly supports Commission action that will enable 5G mobile technologies to thrive above 24 GHz while protecting existing fixed wireless services in these bands.

XO applauds the Commission’s proposal to build its rules and policies in the upper microwave bands on the fundamental bedrock of flexible use. With maximum flexibility, upper microwave licensees will be able to utilize their choice of technology and provide a wide variety of innovative services to customers throughout the United States. As Chairman Wheeler has pointed out, wireless services and technologies continue to dramatically shape the nation’s economy and society, and the Commission should work to foster an environment in which mobile broadband and other services can develop, flourish, and meet the growing demands of consumers using an increasing diversity of devices.

XO generally supports the various elements of the Commission’s proposed licensing and regulatory framework for the Upper Microwave Flexible Use Service (“UMFUS”), but favors certain adjustments to these proposed rules and policies. In particular, the Commission should extend its UMFUS framework to the entire Local Multipoint Distribution Service (“LMDS”) band, rather than just the portion of LMDS spectrum identified in the *NPRM*. On this issue, the

Commission should not be deterred by recent activities at the International Telecommunication Union’s World Radiocommunication Conference 2015. Application of flexible use policies to the LMDS band in the United States will spur innovation and generate enormous public interest benefits, setting an example for the rest of the world. XO also urges the Commission to maintain its existing geographic license areas in the LMDS and 39 GHz bands rather than move to county-based licensing, and to adopt a less onerous population coverage requirement in this early stage of 5G mobile development. In any order in this proceeding, the Commission should clarify how incumbent licensees’ existing authorizations – including LMDS and 39 GHz licenses – will transition to the Commission’s new flexible-use regulatory framework.

The Commission should not apply its mobile spectrum holdings rules and policies to UMFUS spectrum, neither the “spectrum screen” that is applied to secondary market transactions nor any band-specific holdings limit in future UMFUS auctions in the LMDS and 39 GHz bands. Nor should the Commission adopt spectrum sharing rules that would discourage 5G mobile investment in the LMDS and 39 GHz bands, threaten interference to 5G mobile and fixed wireless backhaul, and delay the benefits of these services.

XO appreciates the Chairman’s commitment to rapid action in this proceeding. With a regulatory framework in place, licensees and operators will be able to move quickly to deploy 5G mobile services once manufacturers and vendors have made the necessary technological advances. This aggressive approach will expedite the delivery of critical public interest benefits to American consumers and ensure a leadership role for the United States in the global implementation of 5G technology.

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ATTACHMENT: Reed Engineering, *Maximizing the Utility of the Upper Microwave Flexible Use Service Bands Via Licensee Flexibility and Sound Spectrum Usage Policies*

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COMMENTS OF XO COMMUNICATIONS, LLC

XO Communications, LLC (“XO”) commends the Federal Communications Commission (“Commission”) for proposing a new flexible licensing and regulatory framework that will permit the deployment of 5G mobile radio services in commercial spectrum bands above 24 GHz (the “upper microwave bands”).¹ By making large swaths of upper microwave spectrum

¹ *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services; Establishing a More*

available for mobile broadband development, the Commission will realize extraordinary benefits for American consumers. XO is committed to the innovative use of its licensed upper microwave spectrum, and it strongly supports Commission action that will enable 5G mobile technologies to thrive above 24 GHz while protecting existing fixed wireless services in these bands.

XO applauds the Commission's proposal to build its rules and policies in the upper microwave bands on the fundamental bedrock of flexible use. With maximum flexibility, upper microwave licensees will be able to utilize their choice of technology and provide a wide variety of innovative services to customers throughout the United States. The benefits of the Commission's proposed flexible use approach are described in the attached report from Reed Engineering, *Maximizing the Utility of the Upper Microwave Flexible User Service Bands Via Licensee Flexibility and Sound Spectrum Usage Policies*.² As Chairman Wheeler has pointed out, wireless services and technologies continue to dramatically shape the nation's economy and society, and the Commission should work to foster an environment in which mobile broadband

Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands; Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band; Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services; Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations, Notice of Proposed Rulemaking, 30 FCC Rcd 11878 (2015) ("NPRM").

² *Maximizing the Utility of the Upper Microwave Flexible Use Service Bands Via Licensee Flexibility and Sound Spectrum Usage Policies*, Reed Engineering (Jan. 26, 2016) ("Reed Engineering Paper").

and other services can develop, flourish, and meet the growing demands of consumers using an increasing diversity of devices.³

XO generally supports the various elements of the Commission’s proposed licensing and regulatory framework for the Upper Microwave Flexible Use Service (“UMFUS”), but favors certain adjustments to these proposed rules and policies. In particular, the Commission should extend its UMFUS framework to the entire Local Multipoint Distribution Service (“LMDS”) band, rather than just the portion of LMDS spectrum identified in the *NPRM*. On this issue, the Commission should not be deterred by recent activities at the International Telecommunication Union’s World Radiocommunication Conference 2015 (“WRC-15”). Application of flexible use policies to the LMDS band in the United States will spur innovation and generate enormous public interest benefits, setting an example for the rest of the world. XO also urges the Commission to maintain its existing geographic license areas in the LMDS and 39 GHz bands rather than move to county-based licensing, and to adopt a less onerous population coverage requirement in this early stage of 5G mobile development. In any order in this proceeding, the Commission should clarify how incumbent licensees’ existing authorizations – including LMDS and 39 GHz licenses – will transition to the Commission’s new flexible-use regulatory framework. Finally, the Commission should avoid spectrum sharing rules that would discourage 5G mobile investment in the LMDS and 39 GHz bands, threaten interference to 5G mobile and fixed wireless backhaul, and delay the benefits of these services.

XO appreciates the Chairman’s commitment to rapid action in this proceeding. With a regulatory framework in place, licensees and operators will be able to move quickly to deploy

³ Chairman Tom Wheeler, *Leading Towards Next Generation “5G” Mobile Services*, FCC Blog (Aug. 3, 2015, 3:05 PM), <https://www.fcc.gov/news-events/blog/2015/08/03/leading-towards-next-generation-5g-mobile-services> (“Chairman Wheeler 5G Blog”).

5G mobile services once manufacturers and vendors have made the necessary technological advances. This aggressive approach will expedite the delivery of critical public interest benefits to American consumers and ensure a leadership role for the United States in the global implementation of 5G technology.

I. XO COMMUNICATIONS

XO is a leading nationwide provider of advanced communications, managed network, and IT infrastructure services for business, large enterprise, and wholesale customers.⁴ With its national competitive local exchange carrier facilities, XO operates one of the largest networks in the United States and has a long history of innovation. XO has approximately 20,000 miles of long-haul fiber, approximately one million miles of metro fiber, and more than 4,000 buildings on-net. XO has a planned capital investment of approximately \$500 million over the next several years to bring more buildings on-net in metro areas.

XO's operating affiliate, Nextlink Wireless, LLC ("Nextlink"), currently holds ninety-one licenses in the Local Multipoint Distribution Service ("LMDS") band (covering approximately 770 counties) and nine licenses in the 39 GHz band. XO remains committed to the development of these upper microwave spectrum holdings as a key component of its innovative service offerings. Nextlink is actively utilizing its spectrum assets throughout the country, having deployed over 750 links throughout its LMDS and 39 GHz service areas, and Nextlink continues to deploy additional facilities and links throughout the United States.

Through Nextlink, XO provides its fixed wireless customers with last mile access, cell tower backhaul, and small cell backhaul services. Utilizing new Ethernet technology, Nextlink serves these customers with both point-to-point and point-to-multipoint fixed wireless

⁴ See XO Communications, <http://www.xo.com/#> (last visited Jan. 22, 2016) (containing a company description and service offerings).

configurations, and is also currently exploring the deployment of mesh backhaul facilities where numerous radios establish small-scale, point-to-point links with each other, ultimately connecting designated endpoints. Based on its significant experience operating in the upper microwave bands, XO believes that the LMDS and 39 GHz bands hold enormous potential for the development of 5G mobile radio services.

II. XO'S 5G MOBILE BUSINESS PLAN

XO is committed to the full and innovative use of its licensed spectrum, and it is working diligently to develop a 5G business plan for its LMDS and 39 GHz licenses. In this process, XO must account for the technical and operational characteristics of these upper microwave bands. As the Commission describes in the *NPRM*, the upper microwave bands feature greater propagation losses and shorter transmission paths than commercial mobile bands below 3 GHz. At the same time, given the shorter wavelengths of upper microwave signals, the LMDS and 39 GHz bands support high-throughput services and facilitate spectrum re-use by limiting interference between adjacent cell sites. In these bands, very small antennas can be used at the base station to create highly focused beams toward the mobile devices that compensate for lesser propagation at these higher frequencies.

Given the characteristics of these bands, XO expects that 5G mobile services will be complementary to commercial mobile services provided in the traditional wireless bands below 3 GHz. 5G mobile operations will be most commercially practical in high-density areas such as urban centers, office buildings, retail developments, hotels, and sports venues, and will likely be one element of service packages that rely on lower-frequency wireless bands to ensure ubiquitous service coverage. XO is currently evaluating several different 5G business cases, and its 5G business model will likely evolve through the Commission's rulemaking process and

external standards-setting processes. Ultimately, XO will likely implement a multi-faceted 5G plan that includes a number of business approaches.

Under one approach, XO could deploy an XO-branded 5G mobile wireless network in high-traffic metro areas and enterprise buildings, offering “untethered” mobile and portable wireless services to its enterprise customers. XO could develop applications and services that are customized for a nomadic workforce, taking advantage of high-speed, low-latency 5G networks. Next, in a 5G scenario where XO is a neutral host or provides capacity offload, XO could build out 5G mobile networks in the metro core and leverage its extensive metro fiber transport rings for backhaul and on-net locations for traffic aggregation. XO would likely partner with one or more mobile operators (or non-traditional operators) so their users could roam onto XO’s 5G networks where available. Finally, in geographic areas where XO itself does not build out 5G facilities, it could lease spectrum to other future 5G operators. XO might lease a block of spectrum to a single operator across an entire license area, or more than one spectrum block to multiple 5G operators in those areas.

In all of these business cases, 5G mobile services would coexist with XO’s existing point-to-point, point-to-multipoint, mesh, and other fixed wireless services. As the *Reed Engineering Paper* describes and the Commission points out, the upper microwave bands are “well suited for backhaul and other fixed point-to-point uses because it is possible to have small, highly directional antennas in these bands which, together with the shorter propagation ranges, facilitate extensive reuse [of] microwave frequencies in the same geographic area.”⁵ Given this reality, XO and other upper microwave licensees will continue to use their spectrum to provide backhaul and other fixed wireless services for the foreseeable future. Improved technology as

⁵ NPRM ¶ 22; *Reed Engineering Paper* at 5-6.

well as spatial separation will enable XO and other licensees to coordinate their fixed and 5G mobile operations.

Chairman Wheeler has encouraged industry stakeholders and other interested parties to work both individually and collectively to help unlock the tremendous potential benefits of 5G mobile in the spectrum above 24 GHz.⁶ XO has heard this call and has undertaken a broad-based outreach program in order to maximize the 5G mobile use of its licensed spectrum and other spectrum above 24 GHz. In these outreach efforts, XO hopes to work with a variety of organizations, including U.S. wireless carriers, international carriers, device manufacturers, core equipment manufacturers, standards bodies, academic research institutions, chipset developers, and industry trade associations/groups.

III. XO GENERALLY SUPPORTS THE COMMISSION’S PROPOSED REGULATORY FRAMEWORK FOR 5G MOBILE SERVICES IN THE UPPER MICROWAVE BANDS, WITH SOME IMPORTANT MODIFICATIONS

XO supports most elements of the Commission’s proposed UMFUS framework, which appears well designed to maximize licensee flexibility and promote the development of 5G commercial mobile operations and other wireless services in the upper microwave bands. To realize the full potential of 5G in these bands, however, the Commission should make a number of important modifications to its proposal. The Commission should extend its UMFUS rules to the entire LMDS band, given the current ability of 4G mobile technology and future ability of 5G mobile technology to make use of band segments that are less than 500 MHz (*e.g.*, as narrow as 150 MHz). In addition, based on marketplace realities, the Commission should adopt a license term for UMFUS licensees that is longer than the terms applied to commercial mobile operators in lower-band spectrum. XO also urges the Commission to maintain its existing

⁶ Chairman Wheeler 5G Blog.

geographic license areas in the LMDS and 39 GHz bands rather than move to county-based licensing, and to adopt a less onerous population coverage requirement in this early stage of 5G mobile development. Finally, the Commission should clarify how incumbent licensees' existing authorizations – including LMDS and 39 GHz licenses – will transition to the new flexible-use regulatory framework.

A. The Commission Should Provide Flexible Use Rights to Existing Licensees in the Proposed UMFUS Spectrum

XO supports the Commission's proposal to provide existing upper microwave licensees with the flexibility to operate 5G mobile facilities under the new UMFUS framework. This decision is consistent with Chairman Wheeler's commitment to flexible spectrum use, a "regulatory strategy that allows providers to use spectrum resources to meet their needs and to develop and deploy innovative technologies without Commission approval."⁷ As the *Reed Engineering Paper* points out, "spectrum usage flexibility is now becoming *essential* to maximize (i) the potential of emerging fifth-generation cellular networks and (ii) the variety of innovative new applications that will benefit consumers and enterprises."⁸

The assignment of flexible use rights to existing licensees is the most straightforward and expeditious way to make spectrum above 24 GHz available for 5G mobile use. This approach will minimize transaction costs and provide the fastest transition to expanded use of the LMDS and 39 GHz bands, thereby accelerating the enormous consumer benefits of 5G mobile technologies and services.⁹ As an existing licensee in the LMDS and 39 GHz bands, XO has extensive experience and expertise in the upper microwave bands and will be able to deploy and

⁷ *Id.*

⁸ *Reed Engineering Paper* at 3.

⁹ *NPRM* ¶ 95.

coordinate 5G facilities in a manner that enables those systems to coexist efficiently with existing backhaul and other fixed wireless deployments. As the *Reed Engineering Paper* explains, “[w]here a single licensee offers both fixed services and mobile services in its licensed spectrum, this licensee can dynamically and optimally distribute the radio resources to a variety of services, including (i) communications between the (fixed or mobile) devices and the network, (ii) communications between devices, and (iii) fronthaul and backhaul. Such dynamic allocation of radio resources maximizes spectrum efficiency.”¹⁰

XO agrees with the Commission that the differences between fixed and mobile operations in the upper microwave bands will become increasingly blurred over time.¹¹ Just as existing fixed systems in these bands utilize tightly focused beams between two points, 5G mobile operations will rely on focused beams between base stations and mobile (or stationary) devices. An effort by the Commission to define separate bundles of “fixed” and “mobile” rights would ignore technological realities in these bands and create unnecessary complexity. Integrating fixed and mobile usage rights under unified, flexible use UMFUS licenses is a much more efficient regulatory approach.

As the *Reed Engineering Paper* describes, providing existing licensees with 5G mobile operational authority will facilitate effective management of interference in the upper microwave bands.¹² If the Commission establishes separate fixed and mobile licensees in these bands, there will be substantial coordination challenges and likely significant harmful interference between these licensees’ systems. As the Commission notes, “” [o]ne point-to-point link could preclude

¹⁰ *Reed Engineering Paper* at 10.

¹¹ *NPRM* ¶ 95.

¹² *Reed Engineering Paper* at 8, 10.

mobile use of the spectrum in a downtown region.”¹³ In contrast, a single licensee with both fixed and mobile rights will have incentive to assess the trade-offs of these competing uses, implement an optimal deployment strategy, and minimize interference between such facilities. Furthermore, a 5G licensing approach that relies on the existing geographic area licensing principles in the upper microwave bands “offer[s] the simplest way to prevent harmful interference to other providers of mobile service operating on the same channels, because such interference would need to be managed only along the perimeters of large service areas.”¹⁴

Finally, granting XO and other existing licensees the flexibility to provide 5G mobile services is the most equitable way to implement 5G in these bands. The Commission auctioned the LMDS and 39 GHz bands pursuant to decisions that specifically contemplated future use of these bands for mobile services if associated technical issues could be resolved.¹⁵ The

¹³ NPRM ¶ 95.

¹⁴ *Use of Spectrum Bands Above 24 GHz for Mobile Radio Services; Amendment of the Commission’s Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act – Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band*, Notice of Inquiry, 29 FCC Rcd 13020, ¶ 92 (2014) (“NOP”).

¹⁵ *See, e.g., Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission’s Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services; Petitions for Reconsideration of the Denial of Applications for Waiver of the Commission’s Common Carrier Point-to-Point Microwave Radio Service Rules; Suite 12 Group Petition for Pioneer Preference*, Second Report and Order, Order on Reconsideration, and Fifth Notice of Proposed Rulemaking, 12 FCC Rcd 12545, ¶ 207 (1997) (“1997 LMDS Order”) (“[W]e know of no reason why we would not allow mobile operations if they are proposed and we obtain a record in support of such an allocation. We believe this would be consistent with our goal of providing LMDS licensees with maximum flexibility in designing their systems.”); *Amendment of the Commission’s Rules Regarding the 37.0-38.6 GHz and 38.6-40.0 GHz Bands; Implementation of Section 309(j) of the Communications Act – Competitive Bidding, 37.0-38.6 GHz and 38.6-40.0 GHz*, Report and Order and Second Notice of Proposed Rulemaking, 12 FCC Rcd 18600, ¶¶ 24-25 (1997) (agreeing “that 39 GHz licensees should have the flexibility to provide mobile services” but declining to permit such operations until “inter-licensee and inter-service standards and criteria” for mitigating interference are addressed).

Commission expressly anticipated that it would permit mobile use of the LMDS band if such use was amply supported by record evidence.¹⁶ XO and other licensees therefore paid for their licensed spectrum with the expectation that such mobile use was possible in the future. Such rights are also consistent with the Commission's prior treatment of lower-band licensees¹⁷ and Commission decisions to give terrestrial flexibility to satellite licensees.¹⁸

B. The Commission Should Maximize the Amount of Spectrum in the LMDS and 39 GHz Bands That Can Be Used to Provide 5G Mobile Services

Among the upper microwave bands above 24 GHz, the LMDS and 39 GHz bands spectrum are particularly well-suited for 5G commercial mobile operations. The Commission should incorporate all of the spectrum in these bands into its new UMFUS framework.

As the *Reed Engineering Paper* describes, wireless operators can overcome limited signal propagation in the LMDS and 39 GHz bands and successfully deploy high-capacity 5G mobile facilities in this spectrum.¹⁹ The upper microwave bands' line-of-sight limitations can be

¹⁶ NPRM ¶ 96.

¹⁷ See, e.g., *Amendment of the Commission's Rules to Permit Flexible Service Offerings in the Commercial Mobile Radio Services*, First Report and Order and Further Notice of Proposed Rulemaking, 11 FCC Rcd 8965, ¶ 1 (1996) (allowing Commercial Mobile Radio Service licensees to begin providing fixed wireless services); *Amendment of Part 95 of the Commission's Rules to Allow Interactive Video and Data Service Licensees to Provide Mobile Service to Subscribers*, Report and Order, 11 FCC Rcd 6610, ¶¶ 1-2 (1996) (allowing Interactive Video and Data Service licensees to provide mobile services).

¹⁸ See *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Bands; Review of the Spectrum Sharing Plan among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Band*, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd 1962, ¶ 1 (2003); *Service Rules for Advanced Wireless Services in the 2000-2020 MHz and 2180-2200 MHz Bands; Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz; Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands*, Report and Order and Order of Proposed Modification, 27 FCC Rcd 16102, ¶ 1 (2012).

¹⁹ *Reed Engineering Paper* at 3-5.

addressed through multiple operational techniques, such as multiple input multiple output (“MIMO”), multiple reflected signals, and steerable antennae.²⁰ The technical viability of 5G mobile operations in these bands has been confirmed by experimental testing, which demonstrates the high-speed capabilities of a 5G network at 28 GHz.²¹ For all of these reasons, key companies such as Ericsson, Motorola, and Samsung all support allowing 5G mobile use of the LMDS band.²² Similarly, equipment manufacturers and licensees favor 5G mobile use of the 39 GHz band, and no party has to date provided any reason for excluding mobile operations from this band, which has a global mobile allocation and can support extremely high data rates. The Commission should capitalize on these developing technologies by authorizing 5G mobile operations and encouraging robust 5G deployments throughout these bands.

As the Commission is aware, the International Telecommunication Union’s World Radiocommunication Conference 2015 (“WRC-15”) did not identify the LMDS band, including the LMDS A1 block at 27.5-28.35 GHz (the “28 GHz band”), as one of the bands to be studied for 5G use in preparation for WRC-19.²³ XO shares Chairman Tom Wheeler’s “disappointment[]” that certain parties prevented international studies on the 28 GHz band and

²⁰ See *NOI* ¶¶ 10-13; *NPRM* ¶ 96.

²¹ As the Commission points out in the *NPRM*, research conducted by Samsung, NYU Wireless, and others demonstrates that mobile technologies can theoretically work in the LMDS band. See, e.g., *Press Release, Samsung Electronics Sets 5G Speed Record at 7.5Gbps, Over 30 Times Faster Than 4G LTE*, Samsung Newsroom, Oct. 15, 2014, <http://global.samsungtomorrow.com/samsung-electronics-sets-5g-speed-record-at-7-5gbps-over-30-times-faster-than-4g-lte/>.

²² *NPRM* ¶ 28, citing Comments of Ericsson Inc., GN Docket No. 14-177, at 37 (Jan. 15, 2015) (“Ericsson Comments”); Comments of Motorola Mobility LLC, GN Docket No. 14-177, at 7 (Jan. 15, 2015); Letter from Robert Kubik, Samsung Electronics America, Inc., to Marlene H. Dortch, FCC Secretary, GN Docket No. 14-177, at 2 (Aug. 28, 2015) (“Samsung *Ex Parte*”).

²³ See *World Radiocommunication Conference 2015 (WRC-15), Geneva, Switzerland, 2-27 November 2015*, <http://www.itu.int/en/ITU-R/conferences/wrc/2015/Pages/default.aspx> (last visited Jan. 25, 2015). One of the tasks of WRC-15 was to set the agenda for the next WRC, which is expected to take place in 2019 (“WRC-19”).

other bands, and agrees that “[i]t would have been far better if the Conference had agreed to study the 28 GHz band among the bands they agreed to consider for 5G.”²⁴ At the same time, the results of WRC-15 should not alter the Commission’s treatment of the 28 GHz band and other LMDS spectrum in the instant 5G rulemaking proceeding. On this issue, XO appreciates Chairman Wheeler’s position that WRC-15 “will not slow the activities of this country” and that “the U.S. and other leaders in the 5G arena will go forward with our own studies,”²⁵ as well as Commissioner Jessica Rosenworcel’s view that the Commission “should not be deterred by the failure to include the 28 GHz band” and “should continue to explore this spectrum frontier now.”²⁶

Notwithstanding the recent ITU action, there is a global primary mobile allocation in the 28 GHz band that can be fully utilized in the United States.²⁷ Whatever other national

²⁴ Statement of Chairman Tom Wheeler, *Presentation on the outcomes of the International Telecommunication Union's World Radio Conference that took place in November 2015* (rel. Dec. 17, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DOC-336917A1.pdf (“Chairman Wheeler WRC-15 Statement”). Mindel De La Torre, Chief of the International Bureau, called the failure to include the 28 GHz band in the WRC study process “a lost opportunity for the ITU.” Paul Kirby, *FCC Officials Pledge to Move Forward on 28 GHz Band For 5G*, TR Daily (Dec. 17, 2015) (“TR Daily Coverage of IB WRC-15 Presentation”); *World Radiocommunication Conference 2015 (WRC-15)*, International Bureau, Presentation to the FCC Open Meeting (Dec. 17, 2015) (“IB WRC-15 Presentation”). At WRC-15, the United States supported the Inter-American Telecommunications Commission (“CITEL”) proposal considering spectrum requirements and identifying spectrum band for 5G mobile broadband applications. The CITEL proposal included the 28 GHz band among those identified for future 5G use. See, e.g., *World Radiocommunication Conference, Inter-American Proposals for the World Radiocommunications Conference of 2015*, Inter-American Telecommunications Commission, <https://www.citel.oas.org/en/Pages/PCCII/WRC.aspx>.

²⁵ Chairman Wheeler WRC-15 Statement.

²⁶ Statement of Commissioner Jessica Rosenworcel, *International Bureau Presentation on World Radiocommunication Conference 2015 (WRC-15) (December 17, 2015)* (rel. Dec. 17, 2015), https://apps.fcc.gov/edocs_public/attachmatch/DOC-336912A1.pdf (“Commissioner Rosenworcel WRC-15 Statement”).

²⁷ *NPRM* ¶ 42; Commissioner Rosenworcel WRC-15 Statement; IB WRC-15 Presentation; TR Daily Coverage of IB WRC-15 Presentation.

administrations decide, XO is confident that application of flexible use policies to the 28 GHz band and use of this LMDS spectrum for 5G mobile services in this country will spur innovation and generate enormous public interest benefits for American consumers needing additional wireless bandwidth for broadband. Certainly, rather than have other administrations' positions foreclose such benefits in the United States, the Commission should work to convince *other* nations to reverse course and focus on the 28 GHz band as prime spectrum for 5G mobile development above 24 GHz.²⁸ To this end, XO shares the Chairman's confidence that "as [the U.S.] and others move forward with 28 GHz, an international consensus will develop," and that "other regions will take a much closer look at these bands when they see the progress we will make in our region over the next few years."²⁹ The clear and dramatic benefits of a U.S. 5G

²⁸ XO notes that, in other contexts, the Commission has made spectrum-related decisions that depart from the ITU recommendations and even allocations. *See, e.g., Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, Including Third Generation Wireless Systems; the Establishment of Policies and Service Rules for the Mobile-Satellite Service in the 2 GHz Band; Amendment of the U.S. Table of Frequency Allocations to Designate the 2500-2520/2670-2690 MHz Frequency Bands for the Mobile-Satellite Service; Petition for Rule Making of the Wireless Information Networks Forum Concerning the Unlicensed Personal Communications Service; Petition for Rule Making of UTStarcom, Inc., Concerning the Unlicensed Personal Communications Service*, Third Report and Order, Third Notice of Proposed Rulemaking, and Second Memorandum Opinion and Order, 18 FCC Rcd 2223, ¶ 35 (2003) (in reallocating the 1990-2000 MHz and 2020-2025 MHz bands from the globally harmonized mobile satellite service ("MSS") allocation, the Commission concluded that "interference concerns [to existing PCS operations at 1930-1990 MHz] outweigh the benefits of increased global harmonized spectrum" and reasoned that it could "accommodate the international needs of 2 GHz MSS licensees in the remaining" internationally harmonized spectrum). In this proceeding, the Commission should not hesitate to take the same approach with respect to the 28 GHz band and other LMDS spectrum.

²⁹ Chairman Wheeler WRC-15 Statement. Similarly, International Bureau Chief De La Torre states that the Commission's continued focus on the 28 GHz band for 5G "may set a trend for the rest of the world." TR Daily Coverage of IB WRC-15 Presentation.

mobile framework in the 28 GHz band should trigger future ITU action that supports 5G mobile services at 28 GHz and globalizes these benefits.³⁰

XO agrees with the Commission that satellite interests have failed to present a legitimate basis for excluding 5G mobile services from the 28 GHz band. Fixed Satellite Service (“FSS”) use of spectrum at 27.5-28.35 GHz is secondary to terrestrial LMDS operations in this band,³¹ and, as discussed above, the 28 GHz band has a co-primary mobile allocation throughout the world.³² Satellite operators invested in their operations in this band with full knowledge of their secondary status, and have no reasonable expectation regarding priority access to this spectrum. The Commission should not preclude mobile use of this band solely because of FSS operators’ pre-existing secondary use.³³

The Commission should also revisit the *NPRM*’s proposal for the rest of the LMDS band and extend its flexible use framework for 5G mobile operations to the LMDS A2 and A1/A3/B blocks at 29.1-29.25 GHz and 31.0-31.3 GHz. While the *NPRM* suggests that 5G mobile operations require contiguous spectrum blocks of 500 megahertz or greater,³⁴ evidence in the record shows that spectrum blocks only a fraction of that size can support 5G mobile services.

³⁰ While XO acknowledges the benefits of international harmonization, the failure of other countries to replicate the United States band plan does not provide a valid basis for excluding 5G mobile operations from the 28 GHz band. Different countries have different communications needs and incumbent uses, resulting in a variety of band plans around the world. Tellingly, despite the results of WRC-15, international equipment vendors such as Samsung, Huawei, and Alcatel-Lucent are focusing on the 28 GHz band as key spectrum for 5G mobile use.

³¹ See 47 C.F.R. § 25.202(a)(1)n.7.

³² See 47 C.F.R. § 2.106 (United States Table of Allocations).

³³ Not all satellite operators oppose consideration of the 28 GHz bands for mobile use. EchoStar supports giving existing LMDS licensees the flexibility to provide mobile services along with upgrading the status of gateway earth stations in the band to co-primary. Comments of EchoStar Satellite Operating Corporation, Hughes Network Systems, LLC, and Alta Wireless, Inc., GN Docket No. 14-177, at 22-24 (Jan. 15, 2015).

³⁴ *NPRM* ¶ 70.

Certainly, a 300 megahertz block of spectrum is wide enough for 5G mobile use, and, with advancing technology and increasing reliance on spectrum aggregation across multiple bands, even 150 MHz blocks will likely be sufficient to support 5G mobile operations in the future.³⁵ The *Reed Engineering Paper* states that “even with only 200 MHz spectrum (*e.g.*, a Frequency Division Duplex system with a 100 MHz downlink channel and a 100 MHz uplink channel), 3GPP-defined 4G LTE-Advanced enables 3 Gbps in the downlink and 1.5 Gbps in the uplink.”³⁶ Ericsson and Samsung, specifically, have also suggested that 100-200 megahertz blocks may be appropriate for the 28 GHz band.³⁷ Accordingly, the Commission should include the LMDS A2 block at 29.1-29.25 GHz among those bands where it permits 5G mobile.³⁸ Similarly, existing licensees like XO should be able to provide 5G services in the LMDS A2, A3, and B blocks. In many markets, XO is the licensee both for the LMDS A3 and B blocks and will be able to aggregate 300 MHz of spectrum at 31.0-31.3 GHz.³⁹

If the Commission does not consider permitting 5G mobile in these LMDS sub-bands in its upcoming order at this time, it should issue as soon as possible a notice that examines the 5G transition for these additional LMDS blocks. Going forward, there is no valid technical basis for excluding 5G mobile services from this spectrum.

³⁵ XO notes that 39 GHz licensees have licenses that contain only 50 MHz by 50 MHz megahertz blocks, and the Commission has of course proposed to extend its UMFUS framework to that band.

³⁶ *Reed Engineering Paper* at 7.

³⁷ Ericsson Comments at 37; Samsung *Ex Parte* at 2.

³⁸ While the MSS operator Iridium has previously claimed that 5G mobile operations in the LMDS A2 block at 29.1-29.25 MHz would threaten interference to Iridium’s co-primary non-geostationary-orbit MSS feeder links, XO does not believe that those technical concerns are a legitimate basis for not permitting 5G operations in that sub-band. Comments of Iridium Satellite LLC, GN Docket No. 14-177, at 7-8 (Jan. 15, 2015).

³⁹ *Reed Engineering Paper* at 8.

C. The Commission Should Reject an Overlay Licensing Framework for 5G Mobile Operations in the LMDS and 39 GHz Bands

XO opposes the *NPRM*'s alternative licensing approach for 5G mobile operations in the LMDS, 39 GHz, and other bands above 24 GHz, involving the assignment of overlay 5G mobile licenses. While the Commission has previously assigned overlay rights in other spectrum,⁴⁰ there is nothing in the record that supports an overlay approach in the upper microwave bands. In addition to foregoing all of the critical benefits of the Commission's primary UMFUS proposal (describe in detail above), 5G overlay licensing in the LMDS and 39 GHz bands would create a significant risk of interference to current fixed wireless operations and would diminish existing licensees' rights.⁴¹ As the *Reed Engineering Paper* explains, interference to wireless backhaul or "fronthaul" facilities can affect multiple base stations in a mobile network and large numbers of wireless customers.⁴² An overlay framework would also result in "less efficient and effective" spectrum use, since "[t]wo separate licensees would be unable to quickly (*e.g.*, on the order of few seconds) reallocate radio resources for different services and different users to reflect changes in the traffic patterns and application usage."⁴³

As indicated above, XO is actively utilizing its spectrum assets throughout the United States to provide fixed wireless customers with last mile access, cell tower backhaul, and small

⁴⁰ *NPRM* ¶ 97.

⁴¹ See *Reed Engineering Paper* at 10.

⁴² The *Reed Engineering Paper* states that "[t]he impact of any external interference may not be limited to users of only one base station or eNodeB. When wireless fronthaul and wireless backhaul are used, multiple base stations can be affected by interference. Instead of hundreds of users being affected by interference, thousands of users would be adversely affected. Interference would affect not only the user traffic (*e.g.*, a voice call, email, or video) but also important signaling between the end users and the network." *Id.* at 9.

⁴³ *Id.* at 10. One of the primary benefits of 5G will be lower latency that supports a variety of new applications. *Id.* at 3, 5, 9. The complexity of coordinating spectrum between two separate, co-primary networks could jeopardize this 5G latency. *Id.* at 9.

cell backhaul services, and is currently exploring the deployment of next-generation mesh backhaul facilities. A decision now to assign 5G overlay licenses in the LMDS and 39 GHz bands would undercut existing licensees' long-term efforts to develop this spectrum and would cause significant harm to their customers. The Commission should instead adopt its proposed flexible use UMFUS framework for existing licensees in these bands.⁴⁴

On the other hand, as it has previously indicated, XO supports the auction of new UMFUS licenses in the LMDS and 39 GHz bands in those geographic areas where there is no incumbent licensee due to the return or revocation of licenses in those bands. Just like existing upper microwave licensees, any party obtaining these new UMFUS licenses at auction should have the right to provide either fixed or 5G mobile services in their exclusively authorized spectrum.

D. The Commission Should Not Apply Its Mobile Spectrum Holdings Rules and Policies to the New UMFUS Bands

In the *NPRM*, the Commission asked whether its mobile spectrum holdings framework should be applied to 5G mobile spectrum above 24 GHz.⁴⁵ The Commission should not apply its mobile spectrum holdings rules and policies to this spectrum, including the LMDS and 39 GHz bands. First, XO agrees with the Commission's proposal not to include UMFUS spectrum in the "spectrum screen" that is applied to secondary market transactions. The LMDS and 39 GHz bands are not yet "suitable" and "available" for the provision of mobile telephony/broadband services in the same fashion as other spectrum bands currently included in the screen. As the

⁴⁴ Nor should the Commission allow the provision of 5G mobile services on an unlicensed basis under Part 15 of its rules. Permitting such unlicensed operations in the exclusively-licensed 39 GHz and LMDS bands would create a substantial risk of interference to existing services and also to any new 5G services provided by the existing licensees. XO also addresses the Commission's proposals to permit "use or share" operations in the above 24 GHz 5G bands and opportunistic FSS use of the LMDS A1 block at 27.5-28.35 GHz. *See* section IV, *infra*.

⁴⁵ *NPRM* ¶ 191.

Commission points out, 5G mobile technology for spectrum above 24 GHz is still in its nascent stages, and the 5G mobile standards for these bands are also in their early developmental phase.⁴⁶ Given this reality, it will likely be several years before XO and other 5G mobile operators in the LMDS, 39 GHz, and other UMFUS bands are using their licensed holdings to provide or support 5G mobile services. In addition, as discussed above, this UMFUS spectrum will likely play a complementary role to lower-band holdings in the eventual 5G mobile ecosystem. Just as the Commission has previously excluded the BRS, EBS, AWS-1, and 700 MHz bands from its spectrum screen,⁴⁷ the Commission should for these reasons refrain from applying the screen to the new UMFUS bands.

Nor should the Commission adopt any band-specific holdings limit in future auctions of UMFUS spectrum in the LMDS and 39 GHz bands. Such limits are designed to prevent one or two operators from acquiring at auction most or all of the available spectrum in a band, leaving other competitors without sufficient spectral resources. As it did in the AWS-3 context,⁴⁸ the Commission should find that the auction of UMFUS spectrum without such limits will *not* make it harder for multiple service providers to gain enough spectrum to compete aggressively in the

⁴⁶ *Id.* ¶ 192. The *Reed Engineering Paper* indicates that the full specifications for 5G mobile operations are unlikely to be finalized until 2020, when the ITU may formally approve 5G proposals. *Reed Engineering Paper* at 4.

⁴⁷ See, e.g., *Applications of Nextel Communications, Inc. and Sprint Corporation; For Consent to Transfer Control of Licenses and Authorizations; File Nos. 0002031766, et al.*, Memorandum Opinion and Order, 20 FCC Rcd 13967, ¶ 150, n.338 (2005); *Applications for the Assignment of License from Denali PCS, L.L.C. to Alaska DigiTel, L.L.C. and the Transfer of Control of Interests in Alaska DigiTel, L.L.C. to General Communication, Inc.*, Memorandum Opinion and Order, 21 FCC Rcd 14863, ¶ 30 (2006); *Sprint Nextel Corporation and Clearwire Corporation; Applications For Consent to Transfer Control of Licenses, Leases, and Authorizations*, Memorandum Opinion and Order, 23 FCC Rcd 17570, ¶ 71 (2008).

⁴⁸ *Policies Regarding Mobile Spectrum Holdings, Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions*, Report and Order, 29 FCC Rcd 6133, ¶ 222 (2014).

marketplace. In the AWS-3 proceeding, the Commission “emphasize[d] the availability of a substantial amount of comparable high-band spectrum to competitors and the significant existing holdings of multiple providers of comparable spectrum.”⁴⁹ Similarly, given the volume of flexible use spectrum that is available today above 1 GHz, wireless providers should have ample access to additional high-band spectrum and will not be harmed by the absence of band-specific limits in future UMFUS auctions. Significantly, as technology continues to evolve, additional high-frequency spectrum will become conducive to 5G mobile use, further weighing against the need for these band-specific limits.⁵⁰

E. The Commission Should Modify Its Proposed County-Based Licensing Approach and Performance Requirements

XO opposes the Commission’s proposed county-based licensing scheme for the 28 GHz and 39 GHz UMFUS bands.⁵¹ To promote administrative and operational efficiency in these UMFUS bands, the Commission should instead maintain the existing license areas in this spectrum, Basic Trading Areas (“BTAs”) in the LMDS band and Economic Areas (“EAs”) in the 39 GHz band. With county-based licensing, there would likely be onerous border coordination scenarios in many areas, given that county borders often cut through densely populated areas (e.g., the border between Arlington and Fairfax counties in Northern Virginia). Even more significantly, the combination of county-based licensing and the Commission’s proposed performance requirement of 40% population coverage in each license area would impose undue operational burdens on UMFUS licensees at 28 GHz and 39 GHz.

⁴⁹ *Id.*

⁵⁰ In contrast to its decision in the AWS-3 proceeding, the Commission adopted a band-specific limit for the upcoming 600 MHz auction because it “represents the last opportunity in the foreseeable future for providers to acquire licenses for below-1-GHz spectrum at auction,” and most of the existing sub-1 GHz spectrum is held by only two providers. *Id.* ¶153.

⁵¹ *NPRM* ¶¶ 111-12.

Given the limited signal propagation in the 28 GHz and 39 GHz bands, 5G mobile base stations will likely provide coverage to relatively small geographic areas, often one-tenth of a square mile or less depending on the location of the county and the rain characteristics in that area. Many licensees might be forced to deploy an enormous number of base stations to provide coverage to 40% of the population within their licensed counties, at an exorbitant cost. Deployments costs would be particularly extensive in rural, less populated counties lacking significant population centers. UMFUS licensees might need to deploy facilities that cover almost 40% of the *geographic area* in those counties in order to meet the Commission's proposed performance coverage requirement.

The Commission's proposed 40% coverage rule also fails to account for potential 5G use cases that diverge from traditional cellular service models. As discussed above, 5G mobile operations will likely be most commercially practical in high-density areas such as office buildings, dense retail centers, hotels, and sports venues. While such areas typically include heavy daytime populations, they often do not encompass the residential areas that must be covered to meet the Commission's proposed performance obligation.⁵² Similarly, if an UMFUS licensee's innovative use case focuses specifically on in-building coverage, that operator could deploy hundreds of 5G base stations in indoor environments without achieving any meaningful population coverage under the Commission's proposed methodology assessing signal strength over a geographic census block area.⁵³

⁵² Going forward, it will likely not make economic sense for 5G mobile operators to allocate their UMFUS spectrum resources to residential applications. Residential areas typically lack the reflective topology that enhances signal propagation and reception in these higher-frequency bands. In addition, residential consumer broadband needs will likely be met by in-home Wi-Fi networks delivered to residences through fiber or coaxial cable, minimizing the need for 5G mobile services in those environments.

⁵³ *NPRM* ¶ 207.

Given these factors, the Commission should for now require only 20% population coverage in UMFUS license areas (equal to the current substantial service safe harbor in these bands), with the possibility of revisiting this coverage requirement once 5G mobile technology has matured. By adopting this performance requirement and maintaining the current geographic license areas at 28 GHz and 39 GHz, the Commission will provide UMFUS licensees with greater flexibility and foster innovation and investment in these bands.

F. Other Aspects of UMFUS Regulatory Framework

1. The Commission Should Adopt a Longer Initial License Term for UMFUS Licenses

The Commission should adopt a license term for UMFUS licensees in the LMDS and 39 GHz bands that is longer than the standard 10-year license term for commercial wireless licenses.⁵⁴ While a 10-year license term would be consistent with the Commission's existing rules both in these bands and other commercial mobile bands, conditions in the upper microwave bands warrant a longer license term for new 5G mobile operations. As the Commission has recognized, 5G mobile technology is still in its developmental stages, and it will take longer for UMFUS licensees to deploy and operate commercially viable 5G mobile networks than it takes commercial mobile operators in lower-band spectrum. At a minimum, these factors justify an extended timetable for UMFUS licensees' initial license terms. XO recommends that this initial license term be at least fifteen years in length.

⁵⁴ *Id.* ¶ 121.

2. The Commission Should Extend Its Existing Rules for License Area Partitioning, Spectrum Disaggregation, and Spectrum Leasing to the UMFUS Bands

As it proposes in the *NPRM*, the Commission should extend its existing rules for license area partitioning and spectrum disaggregation to the new UMFUS spectrum bands.⁵⁵ Under these rules, LMDS and 39 GHz licensees (along with the wireless marketplace) will determine the optimal geographic size and bandwidth of their UMFUS authorizations. This flexibility will enable efficient channel planning, varied use cases, and wireless offerings that are better tailored to market demand. The Commission should also extend its existing spectrum leasing framework to the new UMFUS bands to promote efficient, innovative, and dynamic use of this spectrum and foster competition among 5G operators.⁵⁶ With respect to regulatory status, the Commission should permit UMFUS licensees to provide service on either a common carrier or non-common carrier basis (or both), as it does with other commercial wireless licensees including existing LMDS and 39 GHz operators.⁵⁷

3. The Commission Should Adopt Flexible, Variable Channelizations and Channel Bandwidths in the LMDS and 39 GHz Bands.

XO generally supports the adoption of flexible channelization and channel bandwidths in the LMDS and 39 GHz bands. This approach will enable more efficient use of these spectrum bands and facilitate the coexistence of new 5G mobile systems and licensees' existing fixed wireless operations.⁵⁸ With respect to the 39 GHz band specifically, the Commission should

⁵⁵ *Id.* ¶ 232.

⁵⁶ *Id.* ¶ 238.

⁵⁷ *Id.* ¶ 183.

⁵⁸ XO opposes Straight Path's proposal that the Commission disaggregate the LMDS A1 block at 27.5-28.35 GHz into two licenses of 350 MHz and 550 MHz bandwidth. *See* Letter from Russell H. Fox, Counsel, Straight Path Communications, Inc., to Marlene H. Dortch, FCC Secretary, GN Docket No. 14-177, at 3 (Sept. 11, 2015). Maintaining the full, 850 megahertz A1

reject the reconfiguration of that band into wider channels, as well as any other rigid, 5G-related rebanding proposal.⁵⁹ While a revised 39 GHz band plan might suit some license areas, it could have significant, detrimental effects in other markets, including jeopardizing XO's existing frequency division duplexing ("FDD") links in that band. Rather than initiate a top-down rebanding, the Commission should maintain the existing 39 GHz band plan, which features 14 channel pairs with 50 megahertz by 50 megahertz of spectrum. With this band plan and the Commission's proposed 5G rules on partitioning, disaggregation, and spectrum leasing in effect, 39 GHz channelization will be determined on a market-by-market basis depending on the circumstances in each license area. XO believes that this market-based approach should accommodate the development of both FDD and time-division duplexing ("TDD") technologies.

G. Technical Rules for Flexible Use Operations in the UMFUS Bands

1. The Use of TDD or FDD Technology

XO supports the *NPRM*'s proposal to give UMFUS licensees the flexibility to use either FDD or TDD technology for their 5G operations.⁶⁰ XO agrees with the Commission that "there is no need to mandate a duplexing option at this stage of mmW technology research and development."⁶¹ As XO has explained previously in this proceeding, having the option to deploy TDD will enable 5G operators to utilize their spectrum more efficiently.⁶² TDD will enable 5G mobile operators to aggregate multiple sub-channels across different bands in order to realize their throughput goals. In addition, TDD will better suit the expected asymmetrical nature of

block as a single license provides a wide band of contiguous spectrum that can support extremely high data rates.

⁵⁹ *Id.*; *Samsung Ex Parte* at 3.

⁶⁰ *NPRM* ¶¶ 268-70; *see Reed Engineering Paper* at 13.

⁶¹ *NPRM* ¶ 269.

⁶² Comments of XO Communications, LLC, GN Docket No. 14-177, at 6 (Jan. 15, 2015).

mobile data usage and future 5G use cases. A decision to provide UMFUS licensees with the flexibility to utilize TDD technology would also be consistent with the duplexing flexibility that the Commission has provided for other mobile service allocations.⁶³

2. Power, Out-of-Band, and Field Strength Limits

The *Reed Engineering Paper* addresses the proposed technical rules for the UMFUS bands in significant detail, and XO supports the positions and recommendations contained in that analysis. As that report indicates, an appropriate power limit for 5G base stations will ensure that operators can provide adequate 5G mobile signal coverage to their license areas while protecting licensed operations in adjacent geographic areas from harmful interference.⁶⁴ For base stations in the 28 GHz and 39 GHz bands, the *NPRM* proposes an effective isotropic radiated power (“EIRP”) limit of 62 dBm for channel bandwidths of 100 MHz or less, with additional power permitted for bandwidths greater than 100 MHz.⁶⁵ While the Commission notes that this limit is similar to the power limit applied to base stations in the PCS, 700 MHz, and AWS bands, XO agrees with the *Reed Engineering Paper* that this proposed limit is

⁶³ See, e.g., *Amendment of Parts 1, 21, 73, 74 and 101 of the Commission’s Rules to Facilitate the Provision of Fixed and Mobile Broadband Access, Educational and Other Advanced Services in the 2150-2162 and 2500-2690 MHz Bands*, Fifth Report and Order, 29 FCC Rcd 6331, ¶¶ 13, 16, 20 (2014) (relaxing out-of-band emission limits for broadband mobile equipment operating in the 2.5 GHz band, which would “facilitate the use of TDD technologies” and “provide operators with additional flexibility to use the 2.5 GHz band more efficiently and more intensively”); *Amendment of Section 73.202(b), Table of Allotments, FM Broadcast Stations (Elko, Nevada)*, Report and Order, 23 FCC Rcd 14724, App. sec. VI (2008) (discussing the Commission’s out-of-band emission standards “based on flexible rules that permit TDD or FDD operation” in both the upper and lower 700 MHz bands).

⁶⁴ See *Reed Engineering Paper* at 13-14.

⁶⁵ *NPRM* ¶¶ 274-75.

insufficiently high in the upper microwave bands and that the Commission's proposal could constitute a roadblock to 5G mobile development in the United States.⁶⁶

For 5G base stations at 28 GHz and 39 GHz, XO supports an EIRP limit of 82 dBm for the channel bandwidth of 100 MHz.⁶⁷ As described above, transmissions in the upper microwave bands suffer more extensive propagation losses than operations in bands below 2 GHz, resulting in smaller cell sizes. A higher EIRP threshold for 5G base stations at 28 GHz and 39 GHz will enable UMFUS licensees to achieve larger base station footprints, enhancing the quality of their services. This higher EIRP limit also accounts for differences in the number of antennas and channel bandwidths between existing LTE networks and planned 5G networks.⁶⁸ This power limit is consistent with the principle of flexible spectrum use and should prove beneficial to operators and customers alike as the 5G mobile ecosystem evolves.

The *NPRM* also asks whether a higher transmission power limit such as 85 dBm should be applied to fixed facilities used both for 5G mobile service and backhaul service.⁶⁹ For the reasons identified in the *Reed Engineering Paper*, XO supports a higher limit for such facilities. This higher limit will promote flexible spectrum use and support dynamic resource sharing between fixed broadband service, mobile broadband service, backhaul service, and fronthaul service in 5G networks.⁷⁰

⁶⁶ *Reed Engineering Paper* at 13-14.

⁶⁷ *Id.*

⁶⁸ *Id.* at 13.

⁶⁹ *NPRM* ¶ 276.

⁷⁰ *Reed Engineering Paper* at 14.

For mobile stations in the 28 GHz and 39 GHz bands, the *NPRM* proposes an EIRP limit of 43 dBm.⁷¹ Given the greater propagation losses in the UMFUS bands, XO favors a higher power limit for mobile devices in these bands.⁷² In particular, if 5G mobile devices at 28 GHz and 39 GHz are permitted to operate at higher power levels such as 82 dBm per 100 MHz channel bandwidth, such units could be used as “MiFi” devices, enabling Wi-Fi based non-5G devices to have Internet access without incurring 5G service and technology costs.⁷³ At this higher power level, 5G MiFi devices would also achieve greater signal coverage and communications range. While most 5G mobile stations would not operate at 82 dBm, rules that permit the development of MiFi-type devices would promote new deployment paradigms and the provision of innovative services.⁷⁴

With respect to out-of-band emissions (“OOBE”), XO does not recommend a specific OOBE limit for 5G base stations or mobile devices at this time, given that 5G technology is still in its early developmental stages. As the *Reed Engineering Paper* points out, comprehensive studies by 3GPP and other standards bodies will facilitate determination of an appropriate OOBE mask.⁷⁵ XO agrees with the *Reed Engineering Paper* that wide resolution bandwidth such as 20 or 25 MHz are appropriate for OOBE limits in the UMFUS bands, given that 5G networks will

⁷¹ *NPRM* ¶¶ 278-79. A typical LTE mobile station below 1 GHz transmits a maximum EIRP of 23 dBm. See *Reed Engineering Paper* at 14.

⁷² See *Reed Engineering Paper* at 14-15. Samsung suggests the application of an 85 dBm limit for 5G mobile stations, which is the same as the current EIRP limit for existing base stations in the LMDS band. Comments of Samsung Electronics America, Inc. and Samsung Research America, GN Docket No. 14-177, at 35 (Jan. 15, 2015).

⁷³ MiFi is a trademark owned by Novatel Wireless in the United States.

⁷⁴ In order to avoid any biological hazard, this suggested power limit would be applied in conjunction with the appropriate radio frequency (“RF”) exposure limit. The lower of the generic transmit power limit and the exposure-based transmit power limit should be the power limit that is applicable to 5G mobile station. *Reed Engineering Paper* at 15.

⁷⁵ *Id.*

have broader channel bandwidths (100 to 500 MHz).⁷⁶ In addition, XO supports the Commission's proposal to use radiated power tests rather than conducted power tests for OOB compliance,⁷⁷ since the integration of tens or even over a hundred antennas into 5G base stations and mobile station chipsets may create measurement challenges (such as lack of RF power ports) for conducted power tests.

Finally, consistent with its approach to licensing mobile services in other spectrum bands, the Commission should require UMFUS licensees to comply with field strength limits at the edge of their geographic service areas. An appropriate field strength limit will minimize interference to adjacent-area licensees while enabling UMFUS licensees to achieve sufficient service quality and meet applicable performance requirements. As with OOB limits, however, XO does not recommend a specific field strength limit at this time given the nascent state of 5G technology.⁷⁸

H. The Commission Should Clarify How Existing Licensees' Current Authorizations Will Transition to the UMFUS Framework

In its order adopting new rules for UMFUS operations, the Commission should clarify how incumbent licensees' existing authorizations – including LMDS and 39 GHz licenses – will transition to the new flexible-use regulatory framework. In particular, if the Commission shifts to county-based licensing, it should indicate whether existing licensees' BTA or EA licenses will be divided into county-based licenses upon the effective date of the Commission's new UMFUS rules, or at the expiration of the incumbents' current license terms. In addition, the Commission should confirm, as indicated in the *NPRM*, that incumbent upper microwave band licensees can

⁷⁶ *Id.*

⁷⁷ *NPRM* ¶ 284.

⁷⁸ *Reed Engineering Paper* at 15-16.

choose to be subject to the existing substantial service framework at the end of their current license terms, rather than the Commission’s proposed 40% population coverage requirement or some other alternative requirement.⁷⁹ Finally, the Commission should make clear whether other aspects of the UMFUS regulatory framework will become applicable upon the effectiveness of the new UMFUS rules, or instead at the expiration of existing LMDS and 39 GHz licensees’ current license terms.

IV. THE COMMISSION SHOULD NOT ADOPT RULES OR POLICIES THAT PERMIT EXPANDED SHARING OF THE LMDS AND 39 GHz BANDS

In the *NPRM*, the Commission requests comment on potential spectrum sharing in the UMFUS bands by both terrestrial and satellite systems operating on a secondary basis. The Commission should not adopt rules permitting this sharing. Whether by terrestrial or satellite operators, such sharing would create uncertainty regarding the commercial prospects for new 5G mobile services and could jeopardize 5G investment in the upper microwave bands.

A. Use or Share

XO opposes a “use or share” policy for UMFUS spectrum in the LMDS and 39 GHz bands. As described in the *NPRM*, this policy would allow other terrestrial wireless operators to utilize UMFUS licensees’ spectrum in areas where those licensees were not using their frequencies within five years of (i) the effective date of the new rules (for incumbents) or (ii) receiving their licenses (for new licensees).⁸⁰ Rather than adopt a rule that would impose substantial burdens on UMFUS licensees, the Commission should require interested parties to

⁷⁹ In the *NPRM*, the Commission stated that “[i]n order to provide a smooth transition, we propose to apply the existing performance requirement to incumbent LMDS and 39 GHz licensees at the end of their current license terms, so long as the license term expires prior to March 1, 2021.” *NPRM* ¶ 219.

⁸⁰ *Id.* ¶ 216.

rely on the Commission’s spectrum leasing mechanism and negotiate the terms of their access to XO’s frequencies.

As an initial matter, adoption of a “use or share” approach would increase the risk of harmful interference both to existing services and new 5G mobile services in the UMFUS bands.⁸¹ Shared spectrum use is best suited to bands where there is little chance of affecting the operations of existing licensees. In the LMDS and 39 GHz bands, services provided by secondary users could interfere with UMFUS licensees’ 5G mobile operations as well as their existing fixed wireless offerings.⁸² Rather than create a flawed sharing regime, the Commission should focus on policies that help UMFUS licensees integrate their 5G mobile services into their existing service architectures.

Whether involving a Spectrum Access System (“SAS”) or some other regulatory mechanism, a “use or share” policy in UMFUS spectrum would require XO to undertake extraordinarily burdensome activity to avoid interference to its operations and protect critical customer relationships. XO would likely have to set up a registration web portal so that parties using its spectrum could notify XO regarding the nature and location of their operations. XO would have to collect and continually monitor extensive information about what would likely be thousands of service types and facility locations, both for hubs and remote equipment, including technical and administrative information such as power levels, elevation, throughput, deployment date, contact number, FRN number, and other parameters.⁸³ XO would need to

⁸¹ *Reed Engineering Paper* at 12.

⁸² The *Reed Engineering Paper* points out that “if a secondary user operates at the boundary of an UMFUS licensee’s geographic area of license, its operations could pose a threat of harmful interference to UMFUS licensees in adjacent license areas, particularly given the dynamic spectrum allocation and reallocation across fixed and mobile services.” *Id.*

⁸³ Though the registration web portal could be largely automated (at XO’s expense), every addition, deletion, and other change to the database will have to be reviewed by an XO RF

know such information about such secondary systems even in geographic areas where it does not currently have facilities, so that it could request the termination of those operations when expanding its services into those areas. XO would also have to verify this enormous volume of information for its partners and lessees. Overall, XO would have to invest substantial time and resources into the design, development, testing, maintenance, and security of this registration web portal.⁸⁴

Spectrum sharing in the LMDS and 39 GHz UMFUS bands would potentially disrupt XO's customer relationships. Because of these operations, XO's sales force often would be unable to promise the timely provision of services to existing and potential customers.⁸⁵ While today XO typically can fulfill its customers' wireless communications needs expeditiously, a "use or share" approach would require that XO frequently undertake an extended analysis of the RF environment to determine the likelihood of interference to its new, licensed wireless deployments.⁸⁶

engineer for accuracy and completeness. XO would need to know the details of any "use or share" facility when it expands its services into new geographic areas.

⁸⁴ XO would have to promote this portal to multiple industries to assure that potential secondary users know how and where to register. These parties might rely on XO for helping in providing this information, and XO would likely have to establish a help line to assist these parties.

⁸⁵ All of XO's wireless services, whether customer direct or as part of a connectivity solution, have an inherent service-level agreement ("SLA") attached to the service. If a secondary user's operations were causing interference, the SLA might not be met and XO's customer might not receive the contractually agreed-to level of connectivity.

⁸⁶ To determine whether a new deployment would be impaired by secondary users' operations, XO would have to undertake costly "sweeps" of the RF environment in those areas where its customer requested wireless connectivity. XO would likely have to send a two-person team to the area in question to "sweep" the route and look for the secondary users' operations. XO estimates that such RF sweeps can cost as much as \$6,500 for a two-person team, equipment, travel, hotel, and car rental.

If XO identified spectrum sharing operations in an area where it planned a new LMDS or 39 GHz deployment, it would have to initiate the termination of those operations, adding significant time and expense to its deployment efforts.⁸⁷ If a secondary user failed to vacate XO's licensed spectrum on a timely basis,⁸⁸ XO could compel this party to leave this spectrum, but such action could be costly and would delay XO's provision of service to its customers. The Commission should avoid these likely public interest harms by rejecting a "use or share" policy in UMFUS spectrum, at least in the LMDS and 39 GHz UMFUS bands.

B. FSS Operations in the LMDS A1 Block

Since the Commission established its LMDS allocation in 1997,⁸⁹ primary LMDS operators and secondary FSS gateway earth stations have successfully coexisted in the LMDS A1 Block. To date, XO's coordination with geographically limited FSS gateways has been entirely routine. Most FSS coordination requests received by XO are for gateways at rural and remote locations well outside of core urban areas. During 2015, for instance, XO received approximately 50 requests from 6 organizations covering 33 satellite locations, and all of these requests were easily satisfied.

Once the Commission adopts its UMFUS rules at 27.5-28.35 GHz, coordination between licensees' 5G mobile systems and FSS operations should be similarly routine. Like its fixed wireless facilities, XO's 5G mobile facilities will be located predominantly in core urban areas.

⁸⁷ XO would have to notify secondary users regarding the need to end their operations through e-mails, certified letters, telephone calls, or other means.

⁸⁸ For instance, in some instances, the secondary user might be unable to decommission equipment and terminate operations quickly due to the unavailability of its technicians. In other cases, those users might not have an alternate plan for serving their customers and might require additional time to migrate to different spectrum and equipment. Secondary operators' customers might also be public safety entities that, for good reason, need sufficient time to complete that kind of transition.

⁸⁹ *See 1997 LMDS Order.*

In addition, 5G mobile deployments will be low-power, highly directional systems with limited range and aggressive downward angles. Given these factors, there should be no interference issues between these 5G mobile operations and secondary FSS gateways primarily in rural and suburban locations. As it does today, XO will coordinate its 5G mobile services with secondary FSS operators under a cooperative approach.

XO strongly opposes the expansion of FSS operations in the LMDS A1 Block, a development that would upset the successful balance of services in this band.⁹⁰ First, the Commission should reject parties' requests to make FSS gateway facilities co-primary in this band. XO agrees with the Commission that co-primary status for FSS "would be inconsistent with the development of terrestrial Mobile Service in the band,"⁹¹ and supports the Commission's proposed retention of the secondary allocation for this service. Co-primary status for FSS gateways would encumber existing LMDS licensees' frequencies and potentially frustrate their future efforts to build out their UMFUS licenses, including fixed wireless and 5G mobile systems. As the Commission notes, a decision to make FSS co-primary would enable existing FSS operators to "unilaterally place gateway earth stations anywhere there was no current [terrestrial] licensee."⁹² Since 5G mobile facilities would not be in place until after UMFUS rules were established and terrestrial licenses assigned, there could be areas where it would be impossible to implement terrestrial service because of the presence of previously licensed, co-primary FSS gateway earth stations.⁹³

⁹⁰ See *Reed Engineering Paper* at 10-12.

⁹¹ *NPRM* ¶ 130.

⁹² *Id.*

⁹³ As the *Reed Engineering Paper* notes, "[A] significant increase in the number of fixed FSS earth stations . . . could result in substantial geographic areas around the United States in which UMFUS licensees in the 28 GHz band would be unable to deploy fixed or mobile

Rather than elevate FSS to co-primary status in the LMDS A1 Block, the Commission proposes to permit FSS gateway licensees to acquire UMFUS licenses themselves in the vicinity of their gateway earth station facilities.⁹⁴ This proposal appears to be a reasonable means for FSS operators to obtain interference protection for their satellite operations in those geographic areas. If FSS operators place a sufficiently high value on such interference protection, they should be able to acquire UMFUS licenses at auction or on the secondary market and retain those authorizations without having to construct terrestrial systems in those license areas.⁹⁵

Just as XO disagrees with terrestrial “use or share” operations in its licensed frequencies, XO opposes “opportunistic” secondary sharing of the LMDS A1 Block by FSS equipment and devices other than satellite gateway earth stations. Just like secondary terrestrial systems, the presence of widely distributed FSS user terminals and other equipment in the LMDS A1 Block would encumber XO’s licensed spectrum and impede 5G mobile development.⁹⁶ As the *Reed Engineering Paper* states, “[M]aintaining the necessary geographic separation between UMFUS systems and FSS operations in this band would become much more difficult than it is in the current environment, where FSS operations are limited to a small number of gateways with large antennas and narrower beams.”⁹⁷

facilities due to the potential for harmful interference to the FSS gateway facilities.” *Reed Engineering Paper* at 11.

⁹⁴ *NPRM* ¶¶ 132-34.

⁹⁵ In the *NPRM*, the Commission proposes an interim waiver process that FSS gateway licensees could use to gain interference protection outside current LMDS license areas prior to the auction of UMFUS licenses. *Id.* ¶ 145. If the Commission establishes this interim waiver process, any FSS waiver applicant should have to demonstrate that, going forward, terrestrial deployments are highly unlikely in the geographic area at issue and that there is an extremely low probability of future harm to terrestrial services.

⁹⁶ *Reed Engineering Paper* at 11-12.

⁹⁷ *Id.* at 11.

In the *NPRM*, the Commission suggests opportunistic FSS sharing in the LMDS A1 Block could occur through a number of spectrum sharing techniques, including spectrum access systems, beacon signaling, elevation angle limits, and signal cancellation technologies.⁹⁸ Under an SAS approach (as discussed above in the “use or share” context), XO would likely have to devote substantial time and resources to developing a web database for sharing FSS systems. XO would have to collect and monitor extensive technical and administrative information about these FSS systems, and would have to make this data accessible to its partners and spectrum lessees. As with terrestrial “use or share,” the widespread deployment of FSS user terminals would likely disrupt XO’s relationships with numerous customers. XO could not promise interference-free service, and would suffer delays in the delivery of those services.

The other sharing techniques cited by the Commission are either untested or overly complex, likely resulting in substantial burdens for XO and any other LMDS A1 Block licensee. Certainly, a mandate requiring 5G mobile systems to incorporate either unproven beaconing signaling or active signal cancelling technologies would deter 5G build-out in this band. With respect to active signal cancellation in particular, 3GPP work on the physical layer specifications for 5G mobile has yet to begin, and the Commission should postpone consideration of that approach until that technology has been validated in field trials.⁹⁹ Similarly, a requirement that UMFUS licensees in this spectrum be capable of screening out incoming FSS signals above a given elevation angle would frustrate these operators’ 5G mobile deployment efforts. The record in this proceeding does not demonstrate benefits from opportunistic FSS operations that outweigh the public interest harms from this proposal.

⁹⁸ *NPRM* ¶¶ 149-59.

⁹⁹ *See Reed Engineering Paper* at 11-12.

V. CONCLUSION

For the aforementioned reasons, the Commission should expeditiously adopt an order that establishes its proposed UMFUS framework and permits the provision of 5G mobile services in the upper microwave bands. By maximizing the flexible use of this spectrum and enabling existing LMDS and 39 GHz licensees to provide a full variety of wireless services, the Commission can deliver extraordinary benefits to American consumers.

Respectfully submitted,

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ATTACHMENT

Maximizing the Utility of the Upper Microwave Flexible Use Service Bands Via Licensee Flexibility and Sound Spectrum Usage Policies

Reed Engineering

(On Behalf of XO Communications, LLC)

January 28, 2016

Abstract.

The Federal Communications Commission (FCC) is proposing in the Notice of Proposed Rulemaking, FCC 15-138, (referred to as “NPRM” hereafter) to create a new service for the 28 GHz and 39 GHz bands called the Upper Microwave Flexible Use Service (UMFUS) for any form of fixed or mobile service. As part of the UMFUS, existing licensees would be able to offer mobile broadband services in addition to their existing fixed services. The spectrum that is currently unused would be made available via competitive bidding. This paper demonstrates that licensees need flexibility on the use of the spectrum for a variety of scenarios such as fixed wireless data communications, mobile data communications, device-to-device communications, last-mile access for enterprises, backhaul, and fronthaul. Such licensee flexibility will maximize utilization of the UMFUS spectrum. Since no single frequency band would be adequate to meet 5G spectrum requirements, this paper recommends making as much spectrum available as possible by allowing mobile broadband services in all Local Multipoint Distribution Service (LMDS) sub-bands. The paper also recommends transmit power limits based on the power limits for commercial 4G LTE networks and expected 5G characteristics.

1. EXECUTIVE SUMMARY

The Federal Communications Commission (FCC) aims to facilitate the design and deployment of emerging fifth-generation (5G) wireless networks by making high-frequency bands such as the 28 GHz and 39 GHz bands accessible to 5G services. In support of the FCC's overarching goal of ensuring effective utilization of the Upper Microwave Flexible Use Service (UMFUS) bands in support of 5G networks, this paper emphasizes the importance of key aspects such as flexibility for licensees on the use of the spectrum, availability of maximum amount of spectrum, sound use or share policy, and suitable settings for signal transmission parameters.

Spectrum usage flexibility is essential to maximize the potential of emerging 5G cellular networks and to enable proliferation of new and innovative wireless services. Example uses of the UMFUS spectrum include fixed wireless data communications, mobile data communications, device-to-device communications, last-mile access for enterprises, backhaul, and fronthaul. The UMFUS licensees need flexibility in dynamically distributing the spectrum resources for wireless user communications and intra-network communications. We recommend that the FCC grant full flexibility to the UMFUS licensees to determine how, where, and when to use their spectrum resources. Such flexibility will maximize utilization of the spectrum, especially as new 5G applications and services are developed.

The high-frequency UMFUS spectrum is well suited for 5G due to the large amount of spectrum at higher frequencies (*e.g.*, 28 GHz). No single frequency band will be adequate to meet 5G spectrum requirements; operators will need to make use of numerous bands of reasonable width as they implement 5G services in the United States and elsewhere. The NPRM suggests that at least 500 MHz of contiguous spectrum is necessary for a spectrum band to be usable for 5G, but a data rate of more than 1 Gbps is achievable over a 100 MHz channel even with 4G air interface specifications. Much higher data rates would be achievable with 100 MHz spectrum with 5G air interface specifications. Hence, while the NPRM focuses on the Local Multipoint Distribution Service (LMDS) A1 sub-band at 28 GHz, we believe that LMDS licensees should be allowed to offer mobile services also in other LMDS sub-bands (*i.e.*, A1, A2, A3, B1, and B2). In particular, we urge the FCC to allow mobile services throughout the 31.0-31.3 GHz band, consistent with the overarching goals of flexibility and maximizing amount of spectrum available for 5G.

Interference levels in a spectrum band help determine the quality of network performance and user experience. Hence, the policies that result in interference to the primary users of the UMFUS spectrum should be avoided. A limited number of Fixed Satellite Service (FSS) gateways with secondary status can certainly co-exist with primary LMDS licensees. However, proliferation of FSS gateways and/or widespread satellite-based user terminals could create significant interference to UMFUS base stations, mobile stations, and fixed transmitters, and would pose non-trivial challenges to the design and operation of such gateways and satellite user terminals. In addition, we strongly recommend against overlay auctions that could lead to different spectrum licensees in the same geographic area, because of the spectrum coordination challenges between different licensees. Having a single licensee in a given spectrum band for both fixed and mobile services facilitates the management of spectrum shared between fixed services and mobile services and increases the utility of that spectrum.

Suitable limits for transmit power-related metrics should ensure adequate signal coverage and minimal interference between services in adjacent geographic areas. Accordingly, we recommend transmit power limits that are based on prior FCC guidelines, current LTE networks, and expected 5G characteristics. Due to the nascent nature of 5G specifications, we are not recommending any numerical settings for out-of-band emissions (OOBE) and field strength limits near license borders at this time.

Section 2 discusses the flexibility aspects of the UMFUS bands. Section 3 highlights the importance of maximizing the amount of spectrum available for emerging 5G networks, while Section 4 describes the use of the UMFUS bands and analyzes implications of the “use or share” policy proposed by the FCC. Finally, Section 5 comments on parameter settings such as maximum transmit power levels, out of band emission limits, and field strength limits at the license borders.

2. FLEXIBLE USE OF SPECTRUM

Flexibility of spectrum use has always been *desirable* to wireless service providers seeking to maximize the utility of their spectrum. Instead of simply being desirable, spectrum usage flexibility is now becoming *essential* to maximize (i) the potential of emerging fifth-generation cellular networks and (ii) the variety of innovative new applications that will benefit consumers and enterprises.

Examples of UMFUS spectrum uses include fixed wireless data communications, mobile data communications, device-to-device communications, last-mile access for enterprises, backhaul, and fronthaul. While this paper discusses these various use cases, such uses should be viewed as representative examples. In fact, the future use of UMFUS spectrum is difficult to predict at this time and will likely change as technology evolves. Licensees may ultimately use spectrum in innovative ways that may not be apparent today. For this reason, the Commission should provide UMFUS licensees with maximum flexibility in deciding how to utilize their spectrum, especially in the context of emerging 5G cellular networks. This approach will help ensure optimal utilization of spectrum and maximize benefits for consumers.

Standards organizations such as the International Telecommunication Union (ITU) and the Third Generation Partnership Project (3GPP) are actively working on the requirements and specifications for 5G cellular networks. 5G networks are likely to support a variety of futuristic services¹ and will have to meet varying performance requirements related to user data rates (or throughput), area throughput, latency, and error rate depending on the deployment scenarios. Examples of spectrum characteristics, mechanisms, and technologies that will help a 5G network meet these service requirements include substantial contiguity of spectrum, a heterogeneous network (HetNet), antenna techniques such as massive Multiple Input Multiple Output (MIMO), high-performance multiplexing and multiple access techniques, software-defined networking (SDN), cooperative multiband and multi node networks, network functions virtualization (NFV), and Cloud Radio Access Network (C-RAN).

¹ Examples of new services being targeted by 5G networks include extreme real-time communication, Internet of Things (IoT) applications, lifeline communication, and broadband access anywhere (in excess of 50 Mbps even near traditional cell-edge). See “NGMN 5G White Paper, Version 1.0, February 2015” and “ITU-R M.2083-0, IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond, September 2015.”

5G specifications are in the very early stage of being defined, and full specifications are unlikely to be finalized until 2020. For example, specific air interface multiplexing techniques, multiple access techniques, and massive MIMO techniques are currently being evaluated and their exact structures and related requirements will not be known for several years. Even the overall 5G network architecture is unknown at this time. Furthermore, while Next Generation Mobile Networks (NGMN) and the ITU have envisioned certain categories of use cases, actual applications may impose certain unforeseen constraints. Operators will likely require innovative ways of managing the available spectrum. Given the significant uncertainties associated with 5G, it is imperative that the licensees have maximal flexibility in using their UMFUS spectrum.

Flexible spectrum use plays a critical role in facilitating the design and optimization of 5G networks. Section 2.1 shows that UMFUS licensees can contribute toward the success of 5G networks by using the spectrum to serve different purposes (*e.g.*, certain amount of spectrum for user communications and certain amount of spectrum for intra-network communications). Section 2.2 describes the increasing importance of this spectrum to intra-network backhaul and fronthaul links to 5G networks. Section 2.3 describes the need for flexibility in distributing the RF spectrum for user communications and intra-network communications.

2.1 Suitability of 28 GHz and 39 GHz Spectrum for Mobile Consumer Services, Device-to-Device Communications, and Last-mile Enterprise Services

The NPRM proposes the use of the 28 GHz band and the 39 GHz band for fixed or mobile use with geographic area-based licenses. The 28 GHz band (or the “LMDS A1 Block”) is comprised of spectrum at 27.5-28.35 GHz, meaning a total bandwidth of 0.85 GHz or 850 MHz. The 39 GHz band includes spectrum from 38.6 GHz to 40 GHz, meaning a total bandwidth of 1.4 GHz or 1,400 MHz. Both of these proposed UMFUS spectrum bands have the necessary spectral characteristics to support a variety of wireless services. We agree with the FCC’s proposal to provide the geographic licensees in these bands the flexibility to offer both fixed services and mobile services, including mobile consumer services, device-to-device communications, and last-mile enterprise services.

Currently deployed 4G LTE and LTE-Advanced networks typically use two or four antennas per cell or sector.² 5G networks are expected to use many antennas (*e.g.*, greater than 100) per cell. It is impractical to deploy such massive Multiple Input Multiple Output (MIMO) in lower-frequency bands, due to the relatively larger size of antennas in those bands. In contrast, at higher frequencies, it is possible to design and implement massive MIMO, because the antenna sizes are much smaller. For example, if the antenna length is X meters at 1 GHz, it would be (X/28) meters at 28 GHz. The use of massive MIMO enables creation of narrower, higher-gain beams, significantly increasing signal-to-interference ratios and the network and user-experienced data rates.

Allowing 28 GHz and 39 GHz UMFUS licensees to use their spectrum for mobile services will further increase the utilization of the spectrum. Since the standards such as LTE or future 5G include necessary mechanisms to support mobility, user mobility is not expected to degrade spectrum usage compared to the case of fixed users. For example, standards specify adequate guard bands to ensure that out-of-spectrum emissions conform to the spectral emission masks. Interference created by Doppler shifts

² A typical base station or evolved Node B (eNB) covers three 120° sectorized regions. Each such 120° region is referred to as the cell or sector.

introduced by mobility can be handled by mechanisms³ such as suitable carrier (or subcarrier) spacing, adaptive modulation and coding, and hybrid automatic repeat request (H-ARQ).

These UMFUS bands can also be utilized for device-to-device (D2D) communications, where two mobile devices can directly exchange traffic with each other without the traffic passing through the radio and core networks. 3GPP is actively working on specifications for D2D communications. Such communications reduce the latency for machine-to-machine control and would be of tremendous help to public safety users who may need to operate without a communications infrastructure (if rendered unavailable in a disaster scenario). D2D communications are intended for users who are in close proximity, and a high-frequency band such as the 28 GHz or 39 GHz band is useful for such short-range communications. A non-public safety application of D2D communications could include rich multi-media augmented reality to advertise products.

The 28 GHz and 39 GHz bands are also conducive to high-speed last-mile access for enterprises, which enables the enterprises to have broadband connectivity to the Internet. Wireless last-mile access is critical as an effective solution in areas where optical fiber connectivity to the premises is absent, and the use of these UMFUS bands for such last-mile wireless access should be preserved. Even in the case of 4G operations, the need for low-cost backhaul has become a very important issue and limitation.

Finally, small cells – essential elements of 5G – can be deployed in indoor or outdoor environments. Accordingly, UMFUS licensees in these bands should have the flexibility to deploy such facilities both indoors and outdoors.

2.2 Intra-Network Communications: Backhaul and Fronthaul Services

The 28 GHz and 39 GHz bands are conducive to the provision of backhaul and fronthaul intra-network communications services. In a 4G LTE network, the radio network is connected to the core network via backhaul. The backhaul connectivity is implemented using an optical fiber (when available) or a microwave link. LMDS licensees operating in the 28 GHz band have been offering such backhaul connectivity to cellular service providers. Moreover, while LMDS spectrum is already used for backhaul today, the costs of such systems may drop precipitously as components are produced in mass to support the 5G market, leading to even wider backhaul usage of this band. The FCC's flexible use UMFUS framework should enable licensees in these bands to continue to provide these intra-network services.

Fronthaul services have become increasingly important components of wireless networks. The radio network architecture has been experiencing a trend toward centralized or cloud radio access network (C-RAN). In a typical C-RAN architecture, the functions of a base station or eNB are distributed between an RF (Radio Frequency) unit and a baseband unit with fronthaul connecting the RF and baseband units. The fronthaul transports baseband signals in a digital format and requires very high data rates. For example, a typical LTE eNB would require the data rate of a few Gbps on fronthaul. 5G networks would carry much larger amounts of data compared to today's 4G LTE and LTE-Advanced networks. Hence, the data rate requirements on the fronthaul and backhaul will rise significantly.

Similar to backhaul, fronthaul can be implemented using an optical fiber or a wireless medium. The use of optical fiber may be inadequate or the optical fiber may simply not be available at a cell site. Even

³ These mechanisms are already implemented by currently deployed LTE networks.

today, several rural cell-sites and mountainous cell-sites do not have the luxury of an optical fiber. Wireless fronthaul and wireless backhaul are critical to meet data transport needs in these environments. The 28 GHz and 39 GHz bands support both fronthaul and backhaul connectivity and can play an important role in meeting these transport needs.

2.3 Dynamic Spectrum Allocation between User Communications and Intra-Network Communications

An operator in the 28 GHz and 39 GHz bands may use its licensed spectrum for user communications, including (i) communications between the user device and the network and (ii) communications between two devices themselves. Furthermore, spectrum may be used for intra-network communications such as backhaul and fronthaul communications (described above). Flexible use rules will enable UMFUS licensees to efficiently manage these competing uses of their spectrum.

Licensees will need flexibility to dynamically or semi-statically modify their spectrum resource allocation in order to meet continually shifting requirements of fixed and mobile consumers as well as potential fronthaul and backhaul service needs. To address this issue, wireless industry interests are evaluating joint access and backhaul design,⁴ in which spectrum is dynamically partitioned and optimized between user communications and intra-network communications. For instance, in a scenario where a small cell added for capacity no longer demands capacity at a certain time of the day, an intelligent network design can take following actions: (i) turn off that cell, saving energy; (ii) release the spectrum resources being used for communications between the small cell and users; (iii) release the spectrum resources being used for fronthaul and backhaul communications between the small cell and the network; (iv) release the Internet Protocol (IP) networking resources such as IP router functions.⁵ The spectrum resources released as a result of turning off the small cell can be reused elsewhere. Alternatively, if this spectrum is not reused elsewhere, the temporary shutdown of the small cell reduces intra-system interference.

3. MAXIMIZATION OF AVAILABLE SPECTRUM FOR FLEXIBLE USE FRAMEWORK

In the NPRM, the FCC proposes to extend its proposed flexible use UMFUS rules to one portion of the LMDS band, the 28 GHz band (LMDS A1 Block) at 27.5-28.35 GHz. Overall, the LMDS band consists of a total bandwidth of 1,300 MHz in each Basic Trading Area (BTA). Specifically, the LMDS bands includes the following sub-bands: (i) the A1 Band: 27.50-28.35 GHz; (ii) the A2 Band: 29.10-29.25 GHz; (iii) the A3 Band: 31.075-31.225 GHz; (iv) the B1 Band: 31.00-31.075; and (v) the B2 Band: 31.225-31.30 GHz.⁶ As discussed below, we believe that the entire LMDS band should be included within the proposed UMFUS framework, enabling licensees to offer 5G mobile services not only in the A1 Block but also in the other LMDS sub-bands (*i.e.*, A2, A3, B1, and B2).

⁴ Peter Rost, “iJOIN Winter School 2015 - iJOIN System Concept,” <https://www.youtube.com/watch?v=pcsY4KMfAuU>.

⁵ These IP routers, implemented using Software Defined Networking (SDN) and Network Functions Virtualization (NFV) philosophies, use inexpensive commercial-off-the-shelf hardware instead of expensive custom hardware. Intelligent software can bring the IP routers into service and remove them from service dynamically and with flexible and optimal connectivity in real-time.

⁶ Out of the total of 986 designated license areas (*i.e.*, 493 BTAs with each BTA comprising A Block and B Block), 416 areas have active licenses. There are no primary Federal allocations in the 28 GHz band.

The FCC should seek to maximize the amount of spectrum available for 5G mobile use. 5G technology will enable very high average throughput for users as well as very high area throughput. Specifically, 5G wireless networks are expected to provide a peak data rate of 20 Gbps to end users, with average user-experienced data rates of 100 Mbps in a wide area network and 1 Gbps in an indoor coverage area. 5G networks will also likely support area traffic capacity of 10 Mbps/m². According to the ITU, 3GPP, and several NOI commenters, a large amount of spectrum is one of the key enablers of high-throughput 5G networks. Indeed, the ITU identifies three key factors that are critical techniques for achieving 5G high data rates: sufficient amount of spectrum, physical layer enhancements, and network densification.⁷ Theoretical assessment, simulations, measurements, technology development, and prototyping described in the Report ITU-R M.2376 point to the feasibility of utilizing the bands between 6 and 100 GHz to meet the spectrum requirements of 5G deployments.

Clearly, no single frequency band will be adequate to meet the demands of 5G. Rather, a variety of frequency bands will be needed to support 5G needs, and operators will need to make use of numerous bands of reasonable width as they implement 5G services in the United States and elsewhere. Given this reality, the FCC should enable the entire LMDS band to play an important role in this 5G implementation. The network density needed to support 5G data rate requirements makes the deployment of outdoor small cells and indoor small cells crucial. The greater propagation path losses in high-frequency bands such as the LMDS band facilitate containment of RF coverage in small footprints, enabling frequent frequency reuse essential for small cells. Flexible use rules that permit 5G mobile throughout the LMDS band would also yield a larger 5G ecosystem and promote greater economies of scale for 5G.

In proposing to apply flexible use rules only to the LMDS A1 Block, the NPRM suggests that a spectrum band must have at least 500 MHz of spectrum to be useful for 5G mobile operations. We note, however, that even with only 200 MHz spectrum (*e.g.*, a Frequency Division Duplex system with a 100 MHz downlink channel and a 100 MHz uplink channel), 3GPP-defined 4G LTE-Advanced enables 3 Gbps in the downlink and 1.5 Gbps in the uplink.⁸ With the advanced air interface enhancements in 5G, data rates greater than 3 Gbps can be achieved in 200 MHz bandwidth. Thus, bandwidth concerns are not a legitimate basis for excluding the LMDS A2, A3, B1, and B2 Blocks from the UMFUS framework.⁹

⁷ See Section 2.3.9 in “ITU-R M.2083-0, IMT Vision – Framework and overall objectives of the future development of IMT for 2020 and beyond, September 2015.”

⁸ These data rates assume the use of (8x8) MIMO and 64-QAM in the downlink and (4x4) MIMO and 64-QAM in the uplink. While current LTE and LTE-Advanced deployments typically use (2x2) MIMO on the downlink and no MIMO in the uplink, 5G is expected to support many more antennas than 4 or 8 and 256-QAM.

⁹ The NPRM also notes that CORF has urged the FCC to protect the adjacent passive Earth Exploration Satellite Service (EESS) sensing band (*i.e.*, no transmissions are allowed) prohibited through guard bands. Regarding any protection to the adjacent EESS sensing band, the spectral emission masks defined for the LMDS A band would likely be reusable. Additionally, we note that the standards (*e.g.*, LTE and LTE-Advanced) typically include means of adjusting the transmit power levels to meet any stricter emission masks, should the need arise in the future to help the EESS sensing band. For example, in LTE and LTE-LTE-Advanced, the network can broadcast a lower value for the maximum power of the mobile device, although the default maximum transmit power for widely used Power Class 3 mobile devices is 200 mW or 23 dBm. While it is too early to say what 5G signaling will look like, one of the expected outcomes of the 5G standardization process will be a new physical layer (modulation) having reduced adjacent-channel interference issues, specifically to facilitate spectrum utilization. Expected larger propagation path losses and smaller footprints of indoor and outdoor small cells at high frequencies such as 31

In many market areas, the same LMDS licensee currently holds the LMDS A3, B1, and B2 Blocks at 31.0-31.3 GHz. Certainly, this 300 megahertz block of contiguous spectrum provides ample bandwidth to support 5G services and applications. Even in markets where the A3 and B Block licenses are held by different entities, collaboration between licensees could potentially result in 5G mobile use of this 300 MHz band segment. The FCC should apply its flexible use rules to the 31.0-31.3 GHz band, consistent with its overarching goals of licensee flexibility and maximizing amount of spectrum available for 5G.

4. SPECTRUM SHARING AND THE USE OF LMDS SPECTRUM

Effective management of interference increases spectrum utility. Some amount of interference is expected and accounted for in the network planning and design phase, including interference resulting from frequency reuse. A wireless network typically has interference-mitigation mechanisms, which attempt to ensure target performance (*e.g.*, throughput or error rate) even when signal and interference levels fluctuate due to the dynamic nature of the radio environment. Rules and policies permitting spectrum sharing, however, can result in interference issues that have a detrimental impact on a licensee's service to its customers. In this section, we focus on the use of LMDS spectrum and spectrum sharing issues raised by the NPRM.

Below, Section 4.1 discusses the importance of interference-free spectrum to licensees' provision of service and customers' user experience. Section 4.2 demonstrates that the assignment of fixed and mobile rights to the same UMFUS licensee facilitates spectrum management and minimizes interference between fixed and mobile services. Section 4.3 addresses the coexistence of terrestrial operations and FSS in the LMDS band. Section 4.4 summarizes challenges of the "Use or Share Policy" envisioned by the NPRM.

4.1 Importance of Interference-free Spectrum

Interference in a wireless network significantly influences data throughput and the quality of the user experience. A low level of interference helps achieve a high signal-to-interference ratio (SIR), improving network performance and quality of service to end users. For this reason, RF engineers invest significant time and effort in optimizing SIRs in a network.

There are two major types of interference in a wireless network: adjacent-channel interference and co-channel interference.¹⁰ Adjacent-channel interference typically occurs when two wireless systems use spectrum bands that are adjacent to each other in the frequency domain. Co-channel interference occurs when two wireless systems – whether operated by the same entity or different entities – use the same spectrum band in a given geographic area.

When a given frequency band is divided into distinct sub-bands such as Block A and Block B within a geographic license area, adjacent-channel interference exists between the wireless network of the Block A operator and the wireless network of Block B operator. Filters and guard bands (specified by

GHz would also alleviate the overall adjacent-channel interference resulting from fixed or mobile operations in the 31.0-31.3 GHz band.

¹⁰ For more detailed discussions, see Chapter 1 in the textbook "Cellular Communications - A Comprehensive and Practical Guide" authored by Nishith Tripathi and Jeffrey Reed and published by IEEE/Wiley in September 2014.

standards or wireless network operators) help minimize this adjacent-channel interference. For example, a 10 MHz LTE channel involves actual RF transmission in 9 MHz of bandwidth, while the remaining 1 MHz bandwidth functions as the guard band (with 0.5 MHz on each side of the LTE channel). In this scenario, filters attenuate the transmit signal energy to a level that meets the spectral emission mask requirements and minimizes adjacent-channel interference. The combination of guard bands and filters is a very effective and time-tested approach to addressing the problem of adjacent-channel interference.

Co-channel interference is more difficult to manage, due to the overlapping frequency-content of the RF signals. The main solution to co-channel interference is geographic separation of the signal source and the interference source, so that the SIR is sufficient to meet the target quality of service for wireless subscribers.

Reduction of the SIR and the resulting interference impact to a wireless service can have a dramatic, negative impact on user experience. In an LTE network, if the SIR decreases from a very high value to a very low value, the user throughput can be degraded by a factor of more than 70;¹¹ specifically, user throughput could drop from 10 Mbps to only 0.14 Mbps (or 140 kbps) due to this SIR degradation. On the other hand, when interference is minimized, the user experience and spectrum efficiency are optimized.

The impact of any external interference may not be limited to users of only one base station or eNodeB. When wireless fronthaul and wireless backhaul are used, multiple base stations can be affected by interference. Instead of hundreds of users being affected by interference, thousands of users would be adversely affected. Interference would affect not only the user traffic (*e.g.*, a voice call, email, or video) but also important signaling between the end users and the network. Examples of important signaling includes signaling that helps the mobile devices find and stay connected to the network and signaling that provides security.

Having exclusive access to their spectrum helps licensees minimize interference from external sources and meet performance guarantees for customers. Such performance guarantees are a function of the specific services being provided to a wireless subscriber at a given time. For example, for a high-quality voice call, low latency is important, while an extremely low error rate is critical to a streaming video.

4.2 Single Flexible Use Licenses for Fixed and Mobile Services

The NPRM seeks comment on an overlay licensing approach for 5G mobile services in the 28 GHz and 39 GHz bands, as an alternative to its proposal to provide existing licensees in these bands with flexible use licenses that permit both fixed and mobile operations. The FCC asks for comment on the costs and benefits of establishing of such an overlay licensing framework.

¹¹ In LTE, the mobile device reports channel quality indicators (CQIs) that quantify the prevailing channel conditions. A higher CQI value corresponds to a better radio channel. This numerical calculation assumes that the channel conditions change from the best case to the worst case (*i.e.*, CQI=15 to CQI=1) and that 64-QAM modulation scheme and (2x2) MIMO are used when the channel conditions are the best. CQI=1 is associated with the efficiency of 0.1523 bits per QPSK modulation symbol and CQI=15 corresponds to the efficiency of 5.5547 bits per 64-QAM modulation symbol. Considering the impact of (2x2) MIMO, the throughput changes by the factor of $(5.5547 * 2 / 0.1523 = 73)$.

Where a single licensee offers both fixed services and mobile services in its licensed spectrum, this licensee can dynamically and optimally distribute the radio resources to a variety of services, including (i) communications between the (fixed or mobile) devices and the network, (ii) communications between devices, and (iii) fronthaul and backhaul. Such dynamic allocation of radio resources maximizes spectrum efficiency.

In contrast, an overlay licensing approach in the UMFUS bands will create a threat of interference between incumbent fixed wireless operations and new mobile overlay systems. With separate licensees offering fixed and mobile services, spectrum utilization would be less efficient and effective. Two separate licensees would be unable to quickly (*e.g.*, on the order of few seconds) reallocate radio resources for different services and different users to reflect changes in the traffic patterns and application usage.

For example, it is expected that 5G networks will incorporate energy savings features. Effective implementation of such features is more feasible if a licensee enjoys access to and visibility of its entire spectrum band, the quality of service (QoS) needs of fixed and mobile users, and existing resource utilization. In an overlay licensing scenario, an intelligent radio resource management algorithm running in one licensee's equipment would not have real-time access to the resource needs and resource usage managed by another licensee's equipment. The latency in linking competing systems and different licensees' inconsistent goals would create significant technological and regulatory problems. An allocation that is fair from the perspective of one licensee may not be viewed as fair from the perspective of another licensee, and, such perspective differences could lead to continuing conflict. In our view, only semi-static (and not fully dynamic) collaboration of spectrum resources would be possible between different licensees.

Furthermore, prioritization of the resource allocation to meet QoS needs of individual fixed and mobile subscribers requires real-time (*e.g.*, on the order of milliseconds) processing of the prevailing user-specific radio channel conditions, user-specific data (*e.g.*, email with a 5 megabytes of total data), and service-specific QoS for multiple services active for each user. The use of such detailed information is feasible when a given licensee manages both fixed users and mobile users. Management of spectrum resources between competing entities sharing the same spectrum with a quality of service intended by 5G does not seem feasible.

Additionally, radio resource management algorithms are proprietary, and fair and optimal resource allocation is achievable only when such algorithms have full access to detailed information on QoS needs and resource utilization. Resource contention, lack of fairness, suboptimal use of spectrum resources, and the difficulty of determining which licensee would have ultimate control over resource distribution are other major challenges to solve when two different licensees utilize two separately designed and separately functioning proprietary algorithms.

4.3 Co-existence of LMDS and FSS Operations

In the 28 GHz band (LMDS A1 Block at 27.5-28.35 GHz), there is currently a secondary allocation for Fixed Satellite Service (FSS) Earth-to-space operations. According to the NPRM, there are twenty FSS gateway earth stations licensed in the United States and nineteen pending applications for additional FSS gateway facilities. About half of the FSS gateway licenses are in geographic areas with active LMDS systems.

FSS gateway earth stations operating in the 28 GHz band on a co-channel basis have the potential to cause harmful interference to LMDS systems operating in that LMDS sub-band. As discussed in Section 4.1, such interference can significantly degrade the user experience for wireless service customers. Co-channel interference is typically managed via geographical separation of the signal source and the interference source. Thus, in the LMDS A1 Block, LMDS systems and FSS gateways must be geographically separated so that propagation path losses result in adequate SIR at an LMDS receiver or FSS receiver.

A limited number of FSS gateways should be able to co-exist with 5G fixed and mobile users in the LMDS spectrum. To date, LMDS licensees and FSS operators have successfully collaborated and operated their respective systems with sufficient geographical separation and minimal interference issues. Just as fixed wireless services in the LMDS band and FSS gateways can be successfully coordinated, so too can 5G mobile service deployments and FSS gateways. 5G mobile services deployments can be planned based on known locations of a limited number of FSS gateways. Terrestrial cellular operators have routinely worked with other operators to coordinate the spectrum usage at the borders of licensed areas. Thus, we do not anticipate any issues in coordinating the spectrum usage between primary UMFUS operators in the LMDS band and secondary FSS operators, as long as the number of FSS facilities remains approximately at its current level.

We agree with the FCC's current position that FSS earth station operations should not be promoted to co-primary status. This action would provide interference protection rights for FSS gateways and could result in a significant increase in the number of fixed FSS earth stations. This approach could result in substantial geographic areas around the United States in which UMFUS licensees in the 28 GHz band would be unable to deploy fixed or mobile facilities due to the potential for harmful interference to the FSS gateway facilities.

We believe that the FCC should not permit "opportunistic" operations in the LMDS band by FSS user equipment, including FSS equipment on moving platforms. If the FCC permitted opportunistic, secondary FSS operations in the 28 GHz band (27.5-28.35 GHz), including user equipment and equipment on mobile platforms, a very challenging interference environment would emerge in this band. In contrast to the limited number of FSS gateways currently in operation in the 28 GHz band, there could be a large number of FSS user devices in this band distributed widely across the United States. These broadly dispersed FSS operations would threaten harmful interference and performance degradation to UMFUS operations in 28 GHz band. Certainly, maintaining the necessary geographic separation between UMFUS systems and FSS operations in this band would become much more difficult than it is in the current environment, where FSS operations are limited to a small number of gateways with large antennas and narrower beams. We further note that the beams in 5G mobile networks could be quite narrow, potentially resulting in "hidden node" problems. Specifically, by the time a mobile FSS unit senses that it is in a 5G network beam, it will be too late; the link will already have been disrupted. In the case of fronthaul or backhaul links, this problem could have a substantial impact on numerous end users.

The NPRM mentions "active interference cancellation" as one potential mechanism for minimizing interference from FSS facilities to terrestrial flexible use service in the 28 GHz band. In our view, however, this approach is too speculative. In the 3GPP process, work on the physical layer specifications

has yet to begin. We urge the FCC to postpone consideration of active interference cancellation to a later date when feasibility of such approach has been validated in field trials.

The secondary, non-interference status of opportunistic FSS could also compromise the development of FSS equipment in the 28 GHz band. With FSS operators responsible for dynamically identifying (and then avoiding) existing UMFUS systems in a given geographic area in order to minimize mutual interference, FSS equipment would have to have significant processing capabilities that would significantly shorten battery life. It is speculation at this point that such algorithmic capability might develop that would allow sharing between FSS and LMDS operations.

4.4 “Use or Share” Policy and Increased Threat of Interference

The NPRM further proposes that portions of a license area that remain unused after 5 years be made available for shared use by other users on a non-interfering basis. In fact, these secondary “use or share” operations would inevitably threaten harmful interference to UMFUS licensees and would therefore reduce the utility of this spectrum.

If the FCC adopted its “use or share” framework, the systems operated by secondary spectrum users may become widely distributed across a portion of an UMFUS licensee’s license area. These dispersed secondary terrestrial operations could cause harmful interference and performance degradation to UMFUS operations. While the secondary spectrum users would be obligated to terminate their operations once an UMFUS licensee expanded into geographic areas, in some scenarios there may not be sufficient geographic separation between the UMFUS licensee’s operations and the secondary users’ operations, and co-channel or adjacent-channel interference could result. In addition, if a secondary user operates at the boundary of an UMFUS licensee’s geographic area of license, its operations could pose a threat of harmful interference to UMFUS licensees in adjacent license areas, particularly given the dynamic spectrum allocation and reallocation across fixed and mobile services. The secondary user could cause problems similar to the “hidden node” issues described above (*e.g.*, difficulty of maintaining adequate geographical separation between a terrestrial system and FSS equipment, even where the FCC unit utilizes mobile sensing technology).

5. SETTINGS OF TECHNICAL PARAMETERS

As described above, interference plays an important role in determining achievable network performance and user experience. Suitable limits on the transmit power related metrics ensure (i) that sufficient transmit power is available to provide adequate signal coverage and sufficient signal-to-interference ratio coverage to close the communication link and (ii) that interference to an adjacent geographic area is minimal. Below, we discuss various aspects of transmit power, such as transmission power limits for fixed service transmitters, base stations, and mobile stations, and appropriate emission limits and field strength limits at market borders. We also discuss the use of duplexing technologies in the context of 5G networks.

5.1 Duplexing Technique

In the past, the nature of frequency band plans and band channelization have dictated the duplexing method in a band, whether Frequency Division Duplex (FDD) or Time Division Duplex (TDD). Typical incompatibility between FDD and TDD required separation of frequency bands for FDD and TDD. However, we note that flexible duplexing is one of the key themes of the air interface in 5G networks. 3GPP is working on a unified frame structure to facilitate the use of FDD or TDD in a given area. Even in 4G, 3GPP has incorporated the combining of FDD carrier frequency and TDD carrier frequency to aggregate traffic for a given user and increase user throughput. Accordingly, we urge the FCC not to mandate a specific type of duplexing method in the UMFUS bands. Instead, the FCC should allow the wireless industry and licensees to determine a suitable duplexing method as well as associated collaboration mechanisms between the licensees to minimize interference across the licensed areas for 5G spectrum.

5.2 EIRP Limits for Base Stations and Fixed Service Transmitters

The NPRM proposes an effective isotropic radiated power (EIRP) limit of 85 dBm for fixed point-to-point or point-to-multipoint systems, which is the same as the existing Part 101 limit for the 28 GHz band and the 39 GHz band. The NPRM proposes an EIRP limit of 62 dBm for the base stations of mobile broadband services in the 28, 39, and 37 GHz bands. The NPRM notes that the base stations for PCS, 700 MHz, and AWS are limited to an EIRP of 62 dBm (or 1640 watts) per MHz EIRP with an emission bandwidth greater than 1 MHz, and that WCS base stations are limited to 63 dBm (or 2000 watts) EIRP. The NPRM further proposes the limit of 62 dBm for the channel bandwidths of 100 MHz or less and would allow additional transmission power for emission bandwidths greater than 100 MHz for the base stations.

We agree with the NPRM's reliance on the PCS, 700 MHz, and AWS bands as a starting point for 5G mobile broadband services. However, since the NPRM is associating the EIRP value with the channel bandwidth of 100 MHz, we recommend the EIRP limit of 82 dBm instead of 62 dBm for a 100 MHz channel bandwidth, based on (i) typical LTE base station transmit power levels and (ii) differences in the number of antennas and channel bandwidths between existing LTE networks and planned 5G networks.

Current LTE base stations use the High Power Amplifier (HPA) of 40 Watts (sometime even 60 Watts) per transmit antenna in a cell that covers a 180° sectorized region and uses two transmit antennas per cell. Each transmit antenna may have about 12 dB to 14 dB gain. Furthermore, simultaneous transmission of a signal from two antennas would lead to a transmit gain of 3 dB. The use of 60 W HPA and 17 dB overall antenna gain (including the nominal antenna gain of 14 dB and 3 dB simultaneous 2-antenna

transmission gain of 3 dB) yields EIRP of 65 dBm for a 10 MHz channel bandwidth or 55 dBm per 1 MHz emission bandwidth. *These parameter settings would meet the FCC requirement of 62 dBm per MHz or 72 dBm for 10 MHz channel bandwidth for the PCS, 700 MHz, and AWS bands.* A cushion of about 7 dB (72 dBm – 65 dBm = 7 dB) additional gain is provided by the 62 dBm per MHz EIRP threshold.

In this analysis, we extrapolate the currently applicable 62 dBm per MHz for the PCS, 700 MHz, and AWS bands to the 5G UMFUS frequency bands. If we use 100 MHz as the nominal channel bandwidth, the appropriate EIRP value should be (62 dBm value for 1 MHz + 20 dB margin for 100 MHz) = 82 dBm. Consistent with the principle of flexible spectrum use and the deployment challenges of new technology with no prior deployment experience, preservation of the prevailing EIRP threshold of 62 dBm per MHz or 82 dBm for the channel bandwidth of 100 MHz for a 5G frequency band is recommended as a minimum value.

5G networks are expected to utilize numerous indoor and outdoor small cells, and larger propagation path losses would result in smaller cell sizes compared to the existing sub-1 GHz bands. We further note that it is always possible and much easier to reduce the physical footprint of a cell by reducing the maximum transmit power of the HPA and antenna height. Increasing the footprint of a cell is a more difficult problem, and the flexibility of a reasonably high EIRP threshold similar to the EIRP threshold currently applicable to the PCS, 700 MHz, and AWS bands could prove beneficial at a later stage of 5G development. At the very least, the EIRP threshold of 62 dBm per MHz or 82 dBm for 100 MHz channel bandwidth is less likely to constitute a roadblock to 5G deployments than the EIRP threshold of 62 dBm for 100 MHz proposed by the NPRM.

The NPRM seeks comment on whether a higher transmission power limit such as 85 dBm should be considered for in-band applications in which the same equipment is used to for mobile service and backhaul service. In view of the increasing importance of wireless fronthaul and wireless backhaul and the dynamic resource sharing of the spectrum among fixed broadband service, mobile broadband service, backhaul service, and fronthaul service for 5G networks, we support the transmission power limit of 85 dBm. We again note that the NPRM should provide maximum flexibility to 5G licensees, and believe that a lower power limit for equipment used for mobile broadband, backhaul, and fronthaul services could lead to a suboptimal performance for backhaul and fronthaul. Depending upon the specific situation – such as a short distance between the ends of the wireless backhaul or wireless fronthaul links – it will be possible to reduce the overall EIRP by adjusting the transmit power. In contrast, longer distances and very high data rates would make higher transmit power levels more appropriate for fronthaul and backhaul links.

5.3 EIRP Limits for Mobile Stations

The NPRM proposes an EIRP limit of 43 dBm for mobile stations, which is the same as the limit in the 57-64 GHz band under current Part 15 rules. A typical LTE mobile station (of Power Class 3) transmits a maximum EIRP of 23 dBm and is typically used in sub-1 GHz bands. Considering the difference in frequency between current LTE networks below 1 GHz and the UMFUS bands, a higher transmit power for 5G mobile stations is certainly desirable in order to overcome larger path losses in the UMFUS spectrum.

Samsung suggests the use of 85 dBm for mobile stations, which is the same as the current EIRP limit for base stations in the LMDS bands. The combination of the EIRP limit and the applicable RF exposure limit

should be adequate to avoid any potential harm from mobile operations. One potential benefit of greater transmit power for the mobile stations is that such mobile stations, when used solely as MiFi¹² devices, would enable Wi-Fi based non-5G devices to have Internet access without incurring 5G service/technology costs. Range extension and enhanced coverage are other potential benefits of 5G MiFi devices if these devices are allowed a relatively higher EIRP limit such as 82 dBm for 100 MHz (the same limit we recommended for 5G base stations). While we do not expect most 5G mobile stations to operate at 82 dBm, a subset of special MiFi-type devices would benefit from this higher power limit; these devices would help contribute to innovative services and deployment paradigms.

We emphasize that the maximum transmit power limit that we are suggesting must be used in conjunction with an RF exposure limit needed to avoid any bio hazard. The lower of the generic transmit power limit and the exposure-based transmit power limit should be the power limit that is applicable to the mobile station.

5.4 Emission Limits

OBE create adjacent-channel interference (ACI), causing performance degradation to wireless operations in adjacent spectrum. The FCC has generally required licensees to attenuate the unwanted emission power of the base stations and the mobile stations below the transmission power (P) by a factor of at least $[43 + 10 \cdot \log_{10}(P)]$ or $[-13 \text{ dBm}]$ per MHz to limit OBE. The NPRM notes that the tight integration of tens of (or even more than one hundred) antennas into the 5G base station and mobile station chipsets may pose measurement challenges for the conducted power tests. Accordingly, the FCC proposes the use of radiated power tests instead of conducted power tests for OBE compliance.

We agree with the NPRM on the use of radiated power tests rather than conducted power tests, due to practical difficulties such as the lack of RF power ports for measurements of conducted power. Since the industry is at a very early stage of 5G design, we do not recommend any specific OBE levels. Comprehensive studies by standards bodies such as 3GPP will facilitate determination of an appropriate OBE mask. We do note, however, that a wider resolution bandwidth would provide flexibility to the licensees. For example, an OBE mask with 1 MHz resolution has been used for current systems with channel bandwidths of 10 MHz (or sometimes 20 MHz). Since 5G networks will likely have wider channel bandwidths (*e.g.*, 100 MHz to 500 MHz), wide resolution bandwidths such as 20 or 25 MHz are more appropriate in the UMFUS bands.

5.5 Field Strength Limits at the License Borders

The FCC typically establishes field strength limits to minimize interference between licensed systems at the borders of adjacent license areas. As with out-of-band emission limits, we do not recommend any specific field strength levels in the UMFUS bands, given that the industry is at a very early stage of 5G design.

In general, if a field strength limit is too low, the desired signal within a licensee's service coverage area is overly attenuated, and the licensee is unable to provide areas near its license borders with a usable signal. This reduces the utility of a licensee's spectrum and may jeopardize the economic viability of 5G mobile operations, especially in more rural settings. On the other hand, if a field strength limit is too

¹² MiFi is a trademark owned by Novatel Wireless in the United States.

high, adjacent licensees' signals are likely to cause harmful interference to a licensee's own operations, degrading performance and reducing spectrum utility. A balanced field strength limit helps all licensees.

One potential means of identifying an appropriate field strength limit involves determination of the worst-case SIR that would enable a 5G network to operate without significant interference while meeting its applicable performance requirements. A portion of the total interference in a licensee's system could be attributed to the interference generated within the licensee's geographic area, with the remaining portion of total interference then classified as interference from adjacent license areas. Once this inter-market interference contribution could be determined, a suitable field strength limit could be calculated.

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Dr. Reed's area of expertise is in wireless networks, software radios, smart antennas, and communications signal processing. He has authored, co-authored, or co-edited ten books and proceedings, contributed to six books, and authored or co-authored over 350 journal and conference papers. His book on Software Defined Radio is considered one of the earliest and most comprehensive books on the subject. In September 2014, his book on Cellular Networks was published by Wiley and IEEE Press and is a comprehensive review of wireless communication fundamentals and cellular network operations.

Dr. Reed has had numerous commercial research sponsors including AT&T, CTIA, Samsung, Motorola, LG, TI, GM, and Intel; government sponsors including: DARPA, ONR, ARO, JIEDDO, DOJ, and Customs Dept; and government contractors including ITT, SAIC, General Dynamics, Aerospace, IDA, and Raytheon. He is currently the principal investigator on an NSF project to examine enforcement and regulatory technologies for spectrum sharing between commercial wireless and government users. Dr. Reed has had been PI or co-PI on over 100 different sponsored research contracts.

In addition to being the founder of Reed Engineering, Dr. Reed is co-founder of Cognitive Radio Technologies (CRT), a company that is commercializing of the cognitive radio technologies produced for military applications; Federated Wireless, a company that is commercializing spectrum sharing; and PFP Cybersecurity, a company that specializes in security for embedded systems, including Android platforms. He co-founded these companies with his former PhD students. He has also served as a consultant for approximately 38 organizations, covering topics such as merger evaluation, network neutrality, and band planning. Dr. Reed served on the President's Council of Advisor in Science and Technology (PCAST) Advisory Group on how to transition federal spectrum for commercial economic benefits. In 2014, Dr. Reed was selected to be a member of CSMAC, the advisory group on spectrum issues for the US Department of Commerce.

In 2004, Dr. Reed received the Outstanding Industry Contributor Award from the SDR Forum. During 2004, he also received an award from the SDR Forum for his pioneering 2001 publication that provides a mathematical foundation to cognitive radio based on game theory. In 2005, Dr. Reed became *Fellow to the IEEE* for contributions to software radio and communications signal processing and for leadership in engineering education. He serves as a Distinguished Lecturer for the IEEE Vehicular Technology Society and is currently on the Editorial Board for the Proceedings of the IEEE. In 2013, he received the International Achievement Award from the Wireless Innovations forum for the impact of his accumulated research. In 2014, Dr. Reed served as co-general chair for the IEEE Dynamic Spectrum Access Network (DySPAN) conference. Dr. Reed testified before Congress in 2015 on the issues of spectrum management.